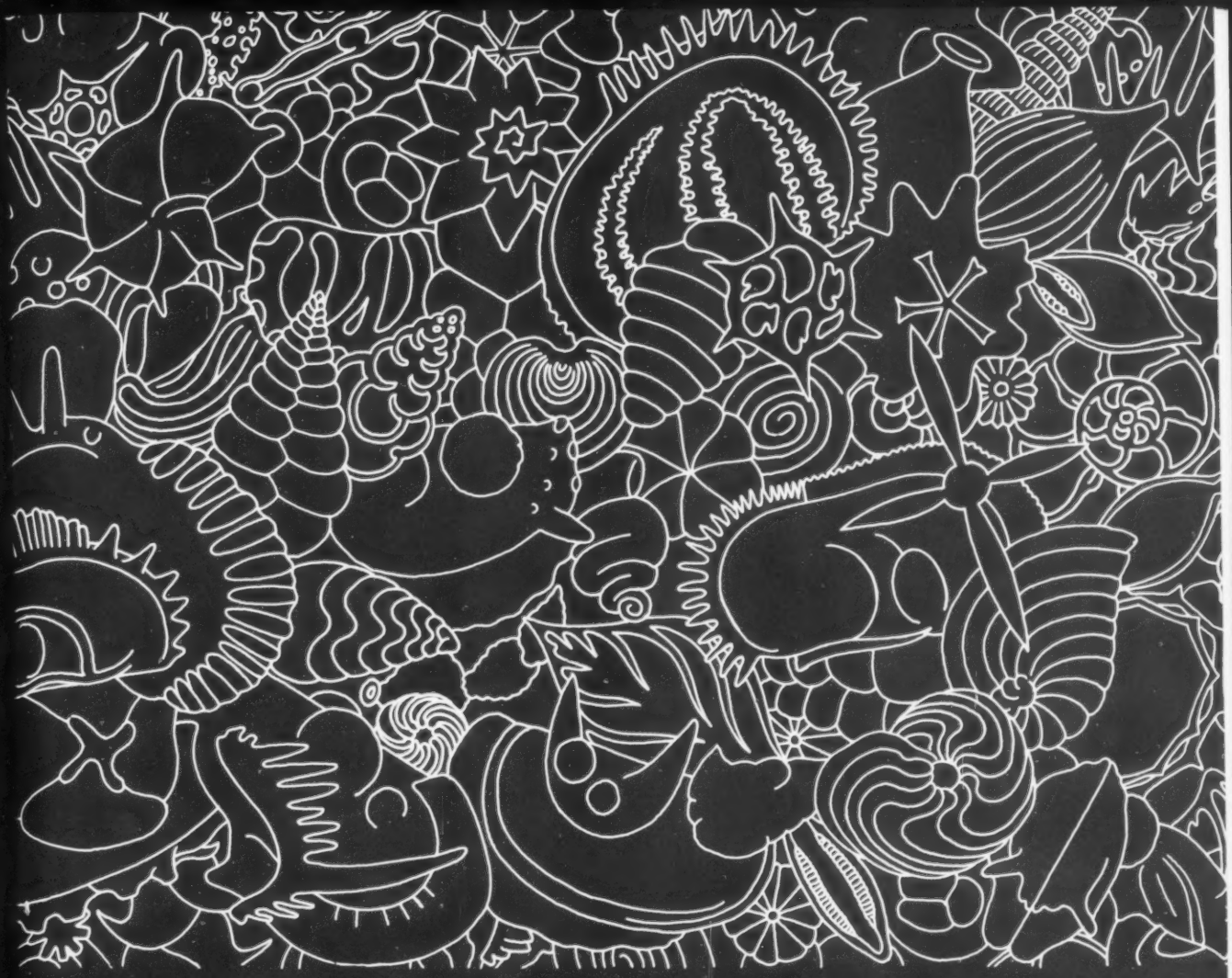


micropaleontology

volume 7
number 2

april 1961

Published by:

DEPARTMENT OF MICROPALEONTOLOGY
AMERICAN MUSEUM OF NATURAL HISTORY
CENTRAL PARK WEST AT SEVENTY-NINTH STREET
NEW YORK 24, NEW YORK

micropaleontology

articles

Coccolithophorids and related Nannoplankton of the early Tertiary in California ... M. N. BRAMLETTE and F. R. SULLIVAN 129

The status of the foraminiferal genera *Ammodiscus* Reuss, and *Involutina* Terquem .... ALFRED R. LOEBLICH, JR. and HELEN TAPPAN 189

Pollen of the genus *Aquilapollenites* ..... JOHN W. FUNKHOUSER 193

Foraminiferal ecology around the Orange County, California, ocean sewer outfall .. JAMES G. WATKINS 199

Torispora securis Balme: Spore or sporangial wall cell? ..... G. K. GUENNEL and R. C. NEAVEL 207

Bibliography and index of conodonts, 1949–1958..... SIDNEY R. ASH 213

news reports

Israel..... Z. REISS 245

Portugal – Overseas ..... ARMENIO TAVARES ROCHA 247

United States – East Coast ..... RAYMOND C. DOUGLASS 248

United States – Mid-Continent Region ..... DOROTHY J. ECHOLS 251

Venezuela ..... BOGUSŁAW J. SZENK 256

The price of this quarterly is $12.00 per year for personal subscriptions; all others, $15.00 per year. Single copies are $4.00 each.

ABSTRACT

Evidence of the stratigraphic value of the fossil remains of an abundant and varied calcareous nannoplankton has been limited by little published data. Description of the species and tabulated distributions in 86 samples from a continuous sequence of Paleocene and Eocene strata of California permit recognition of six distinct biostratigraphic units. Available evidence on their extension as zones elsewhere and relations to type areas of some European stages are presented.

Coccolithophorids and related Nannoplankton of the early Tertiary in California

M. N. BRAMLETTE AND F. R. SULLIVAN
Scripps Institution of Oceanography
La Jolla, California

INTRODUCTION

The great variety of the tiny (2–30μ) fossil remains of the calcareous plankton which includes coccolithophorids has become apparent from recent studies. In rocks of Tertiary and late Mesozoic age, they form the major constituent of some chalks, are very abundant in many clay or shale formations, and may be found in some clayey sandstones. Wide geographic and restricted time distribution of many distinctive forms is now evident, although little of this information has yet been published. Much work is obviously required in the description of species, with records on their occurrence, for more general application of these microfossils promising to stratigraphy. Study of a sequence of many samples through a considerable part of the Tertiary seems a necessary task for any broader investigation. The local ranges of taxa may be of little significance elsewhere except as they are combined into broad stratigraphic zones by certain coincidences and partial overlaps of ranges and the succession of such zones established. The sequence of samples also offers evidence on the phylogeny of the few forms with lineages indicated by morphologic changes in the succession of strata of the one area.

Investigations of the coccolithophorids, which constitute a major element of the plankton in the present oceans, and especially of the taxonomic and related problems, have received considerable attention from marine biologists. The taxonomic problems are difficult, however, even with the living forms. Although the coccolithophorids are usually classed as unicellular algae, zoological nomenclature has been commonly applied and is followed here, as perhaps is justified by their protistid character, discussed later. Relations among many of the extinct forms are quite obscure, and the form species can only be placed in genera *incertae sedis*. Despite the artificial classification now necessary for the fossil species, delimitation of their character and distribution permits applications to biostratigraphy.

The type specimens, with their positions indicated on slides of the sample assemblages, are deposited in the U. S. National Museum, and their Museum numbers are included here. Sets of assemblage slides which include topotypes have been sent to the American Museum of Natural History in New York and the École Pratique des Hautes Études in Paris, and another set and part of the original samples remains at Scripps Institution of Oceanography.

ACKNOWLEDGMENTS

A part of each of the 110 samples collected from Lodo Canyon by the U. S. Geological Survey was generously supplied for this study. The measured section is also reproduced from U. S. Geological Survey Professional Paper 240A (1951). Samples from the stratigraphically higher strata of Oil City and Garza Creek were kindly supplied from measured sections of the Union Oil Company of California and the Texas Company of California. Our many samples from Europe and elsewhere were supplemented by additional ones from sources too numerous to enumerate here. Helpful information and discussion from G. Deflandre of Paris, E. Kamptner of Vienna, E. Martini of Frankfurt, and others are appreciated, and especially those of our colleague W. R. Riedel. A grant from the National Science Foundation helped to finance the investigation and is gratefully acknowledged.

PREVIOUS INVESTIGATIONS

The early investigations in this field have been summarized in other papers and need not be reviewed here, except for a few brief remarks. Fossil remains of some of the calcareous nannoplankton (including coccolithophorids and discoasters) were figured more than a century ago by Ehrenberg (1836, 1854). He considered them, however, as inorganic "crystall-drusen," and their true nature was recognized only through the work of Huxley (1858), Wallich (1860), and Sorby (1861).

Much systematic work on the major groups of living Coccolithophoridae began with Lohmann (1902), followed by Schiller (1930) and Kamptner (1941). Braarud and associates in Oslo are now most active in this field and have utilized the electron microscope for detailed study of many very small forms of the modern plankton.

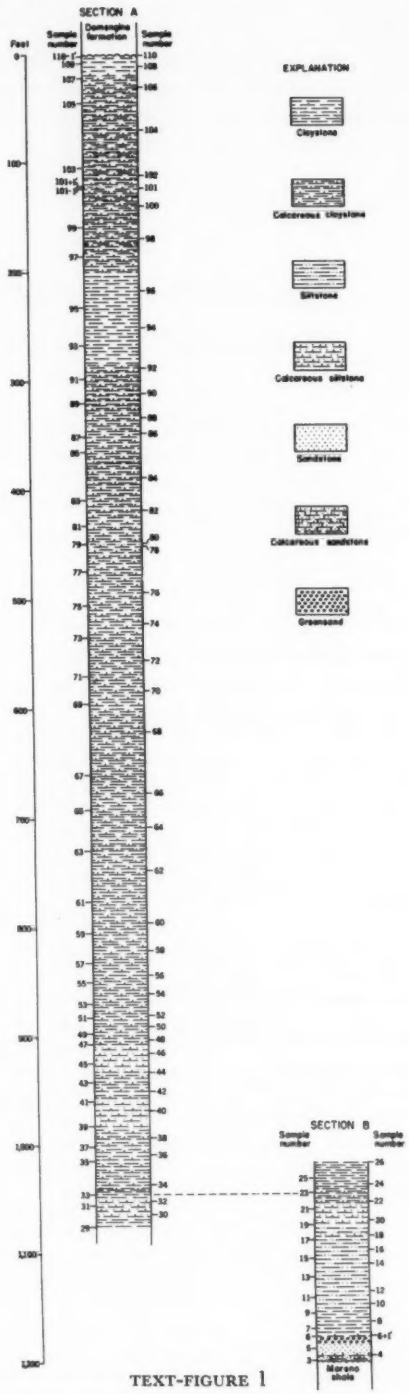
Tan Sin Hok (1927) presented the first systematics on a fossil group of this calcareous nannoplankton, which he named *Discoaster*. Deflandre (Deflandre and Fert, 1954) has described a number of other genera *incertae sedis* and has given a general discussion and classification of the calcareous nannoplankton, including living and fossil forms (1952*a*, *b*).

Few workers have investigated the fossil forms from a stratigraphic viewpoint, but a preliminary paper by Bramlette and Riedel (1954) emphasized this aspect and their possible value for age assignments. Increasing interest is indicated by papers of Chamrai and Lazareva (1956), Noël (1956), Martini (1958, 1959), Stradner (1958, 1959), and others.

SAMPLES STUDIED AND THEIR STRATIGRAPHIC RELATIONS

The samples from the type section of the Lodo Formation are small parts of 110 samples collected at about 10-foot intervals by the U. S. Geological Survey, for study of the foraminiferal faunas by M. Israelsky. Part of his work has been published as Professional Paper 240A (1951) and 240B (1955), from which our columnar section (text-fig. 1) is reproduced to indicate the sampled intervals. The basal part of the formation was sampled from the better-exposed strata indicated as section B, which is about 200 feet south of the main section A. Correlation of the two parts of the section was based on similarities in lithology and foraminiferal faunas in some overlapping samples in the two sections. A very good correspondence of that correlation with the one indicated by this study is evident from the distribution of species shown in Table 1 in the overlapping samples of the two parts of the section.

This well-exposed section of the Lodo Formation is in northwestern Fresno County in central California, and the exact locality is shown on the geological map published in Professional Paper 240A. Foraminiferal



TEXT-FIGURE 1

COLUMNAR SECTIONS OF LODO FORMATION, SHOWING STRATIGRAPHIC POSITION OF SAMPLES
(from Geol. Surv. Prof. Paper 240A)

and other studies have indicated a Paleocene age for the lower 200 feet of strata, which are overlain by the much greater thickness of Lower and perhaps Middle Eocene strata of the formation. As interpretation of our data gave little evidence for a Middle Eocene age for the upper part of the Lodo Formation, a few additional samples were included as supplementary data from overlying formations of better-established Middle Eocene age.

The Domengine Formation, which immediately overlies the Lodo Formation, is generally assigned to the Middle Eocene from molluscan and foraminiferal faunas and other evidence. It is dominantly a sandstone in which fossil nannoplankton are rare or absent, but silty shale beds in the upper part contain many of these microfossils. Although they are present in the upper Domengine above the type Lodo section, the assemblage of these fossils is much better represented along the strike to the south, and the occurrences shown in Table 1 are from these more southern areas, indicated as follows:

Sample OC-1 is from a shale bed within the middle part of the Domengine Sandstone at Tumey Gulch, 4 miles southeast of the type Lodo section. Sample OC-2 is from a shale bed in the upper Domengine, 11 feet below the glauconite bed at the top of the formation, in the Oil City section located 9 miles north of Coalinga. Sample OC-3 is from this Oil City section, in the Canoas Member of the basal Kreyenhagen Formation, 30 feet above sample OC-2. Sample OC-4 is also from the Canoas Member in the Oil City section, only 4 feet above sample OC-3.

Samples GC-1, GC-2, and GC-3 are from the Canoas Member of the basal Kreyenhagen of the type region in Garza Canyon, 4 feet, 30 feet, and 52 feet, respectively, above the base of the Canoas. The base is poorly exposed here, but a sample from the basal bed along the strike southward indicates closer equivalence with OC-4 than with GC-1. A few additional samples which overlap these separated short sections were examined, but less thoroughly, and so are not included in Table 1. Samples from the intermediate Coal Mine Canyon section were also examined, and relations between the Canoas of different areas is considered in the discussion of correlations. Samples from many other parts of the world, including the type areas of some European stages, have had preliminary study, and the occurrences of species in these samples are indicated in the systematic descriptions.

METHODS OF STUDY

These very small fossils pose some special difficulties in their study, and techniques have not yet received adequate attention. Some simple and rapid methods were necessary for the examination of the many samples required to gain any idea of their distribution and value in biostratigraphy, and this procedure is briefly outlined. More elaborate studies, including examination with the electron microscope, will be needed in attempts at a more satisfactory classification.

Disintegration of the very small sample (less than 1 cc. is needed) commonly requires only soaking in water with some agitation, ultrasonic equipment being advantageous for indurated samples. More drastic treatment is seldom needed, as the tiny microfossils are apt to be poorly preserved and doubtfully identifiable when isolated by disintegration of much lithified shale or limestone.

Concentration of the fossils by some means of separating them from clastic particles of comparable size has not yet proved satisfactory. A pipette sample taken after an appropriate settling time will eliminate most particles above 30–40μ. Another settling within the pipette permits discarding a drop which includes other particles larger than about 30μ, and this is followed by placing two or three drops from the pipette on a large glass slide before much of the finest clay-size material (less than 2–3μ) has settled out. The material is spread on the slide and dried on an electric hot-plate; Canada balsam with xylene is then spread over it and a large cover glass pressed on to complete the simple preparation for microscopic examination. Before microscopic study it is usually desirable to dry the balsam by leaving the slide in an electric oven for several weeks, in order that specimens may become fixed in position if their coordinates from a mechanical stage are to be recorded.

Known species are usually identifiable in such a permanent Canada balsam slide, even though fixed in one orientation. For study and description of new forms, however, various orientations are necessary, and a second slide for this purpose may be prepared from additional drops from the same pipette sample. After being spread and dried on the slide, the fine material is scraped together from the tight adherence on the slide and dispersed in a few added drops of a viscous liquid such as the silicone Kel-F (Cargille Laboratories, New York). A large cover glass on such a preparation can be shifted around sufficiently to vary the orientation of the specimen under microscopic view. Advantages of the silicone over a viscous Canada balsam with xylene include its lower index of refraction, providing greater relief of calcite elements in most orientations, and the fact that this preparation will remain indefinitely viscous and inert to the calcite skeletal remains. Mounting media such as diaphane (Will Corp., Rochester, N. Y.), in which specimens show more relief than in Canada balsam and which will harden into permanent mounts, may prove useful for some purposes.

A magnification of about 500× is convenient and sufficient for most examination and photography, although double this magnification with an oil-immersion lens is necessary for the study of the smallest forms (less than about 5μ) and for details of some larger forms. A microscope with binocular head is obviously a great advantage, but this needs to be combined with polariz-

ing equipment and a rotating stage, such as those now available in the Zeiss Standard WL Pol microscope.

The appearance under polarized light, and especially with crossed nicols, is very distinctive for many species and indicates the diagnostic microstructure of the large groups of heliolithid or ortholithid character (Deflandre, 1950) discussed under taxonomy. The extinction position of the calcite elements and the curvature of the extinction lines resulting from the crystallite arrangement in coccoliths and other forms of heliolithid character are important, not only for recognition of specific differences, but also for indicating whether the specimen under microscopic examination is oriented with the distal or proximal side up. Sinistral curvature of the crossed extinction lines consistently indicates the distal side of all coccoliths of the genus *Discolithus* examined, but dextral curvature of the extinction lines in distal view is usual for certain other groups, as indicated in the systematic descriptions. Questionable orientation in plan view of oval-shaped coccoliths, fixed in a permanent mount, can also be resolved by rotation of the stage to another position under crossed nicols. In this position, the two extinction-line arcs of the oval forms resemble those of the bisectrix interference figure of a biaxial mineral, and the position with the two arcs most separated relative to the orientation of a polarization plane indicates which side of the coccolith is oriented upward. Some of the forms photographed with crossed nicols are shown with the two arcs thus separated (pl. 2, fig. 9c), and others are photographed with orientations at 90 degrees to that position and thus show the curvature of the crossed extinction lines (pl. 2, fig. 5b). Study of the extinction lines in various positions of rotation of the stage, especially with the use of a universal stage, could provide other data on the crystallite arrangement or microstructure (Kamptner, 1954) otherwise evident only from electron microscope examination. Some species are more conspicuous and show a more distinctive character with crossed nicols than in normal transmitted light, as illustrated in plate 3, figures 1a, 1c, and plate 7, figures 11–12.

Some use has been made of a process for replacing the calcite of the skeletal remains with fluorite by treating a sample with dilute hydrofluoric acid. This treatment eliminates most of the clay and other fine clastic particles, thus concentrating the specimens, and the general form and even most details of specimens are surprisingly well replaced by the fluorite (see pl. 2, fig. 3). However, the important structural characters revealed by examination in polarized light cannot be determined after replacement by the isotropic fluorite.

Small forms (less than 4μ) are not distinctive unless studied with the electron microscope, and therefore have been neglected in this study. The electron microscope has shown quite distinctive characters for coccoliths only 2–3μ in size, and remarkable details appear, especially in carbon replicas from which the original calcite, opaque to the electron beam, has been dissolved. Although such detailed study is essential for an improved classification, it seems hardly practicable for obtaining much information in the near future on the distribution of fossil forms in space and time, which requires examination of the many forms in each of many samples. The form taxa recognizable otherwise may thus ultimately be subdivided by such detailed studies, but this should only refine and not seriously alter any previous biostratigraphic interpretations.

Not only the smallest forms have therefore been neglected here, but also some nondescript forms of larger size, which show little character for satisfactory specific definition and recognition elsewhere. The genus *Thoracosphaera* (pl. 9, fig. 11) is not recorded in the tabulation because most specimens of this large and robust form were eliminated in the settling separation. Their recovery by special treatment seemed of little value because it is doubtful that more than one species of *Thoracosphaera* is recognizable, similar forms ranging throughout the Tertiary and still living. Rare lopadoliths (pl. 5, figs. 19–20) likewise are not recorded.

Although the photographs of many specimens are not very satisfactory because high magnification gives little depth of focus, such reproductions are obviously more realistic and objective than the supplementary drawings. Refraction of light into some specimens may produce lines and effects that could be misleading unless the focus were varied, but the focus selected for the photographs is intended to minimize such effects. The depth of focus in side- and oblique-view orientations made drawings of these views seem advisable, especially as such orientations were obtained in the viscous mounting medium with specimens first identified in the usual plan view. However, a few specimens were successfully photographed in this viscous liquid, which indicates that this process might have been more commonly utilized. In order to resolve questions of orientation of specimens photographed in permanent slide preparations, sketches of the extinction lines between crossed nicols were made after the specimens had been oriented with their distal sides upward in the viscous medium.

The distribution shown in Table 1 is intended to indicate very approximately the order of relative abundance of the species listed. It is not based on counts, which seemed doubtfully justified for the purposes of this study. The symbols for common and abundant may therefore not be entirely consistent, and they undoubtedly overlap; the same is true of the symbols for common and few and for few and rare, but any greater discrepancies than these are improbable. The symbol for few is intended to indicate about 10 specimens out of perhaps a thousand noted among the many more that were included in most slides. Even the rough approximations should be significant, however, and may aid in the recognition of topotype specimens, although few species were described without a considerable number of specimens for examination.

PROBLEMS OF INTERPRETATION

Apart from the usual taxonomic problems and those related to the interpretation of age and other relations of the assemblages (discussed under special headings), two problems present greater difficulties than with most groups of fossils. The small size and delicacy of these forms results in poor preservation from diagenetic changes in some strata. Corrosion and secondary deposition of calcite thus may modify specimens so much that identification with any assurance is impossible. Another result of their very small size and great abundance is that fossil specimens are easily reworked from eroded strata and may be widely redistributed. Both of these problems require preliminary study and experience in the field of work, and critical observations and consideration of the evidence. Much confused and misleading data may thus appear in papers representing a first investigation with no consideration of these serious problems.

Partial or complete solution of such tiny calcareous forms is common on the deeper parts of the present ocean floor. Solution because of comparable conditions seems unlikely in the shallower-water accumulations of most strata, although solution is possible in accumulations associated with much organic matter. Many occurrences of marked corrosion and particularly of secondary growth seem, however, related to a diagenetic process after burial, generally increasing with greater burial and age and with deformation of strata. Secondary recrystallization may largely or completely obliterate recognizable remains in some fine-grained limestones, as was indicated for some of Cretaceous age (Bramlette, 1958). Unusually heavy specimens with abnormal amounts of calcite in some other occurrences, however, may be due to heavy growth of the nannoplankton in surface waters that were especially favorable for calcite deposition. This is suggested in samples where only certain species show an unusually heavy form and especially in such occurrences as Lodo samples 37 and 38, where specimens are generally heavier than those in samples immediately below or above and thus with no differences in depth of burial or other evident factors that might affect diagenetic processes.

Familiarity with distinctive species in various occurrences may permit identification with some assurance in an occurrence where specimens are considerably heavier than normal. However, identifications and descriptions of new species have been made by some workers from samples in which the specimens were too greatly modified by corrosion or secondary growth to be of any value.

These fossils, generally ranging between 2 and 20μ, may be easily transported after erosion from older strata. This reworking and redistribution is very important in some regions where such tiny fossils are common in the source rocks of later deposits and is especially striking in regions near the Pyrenees and Alps. Many other regions, however, show a succession of species ranges constituting zones without indications of the admixture of specimens from older strata, which were either barren of such fossils or were not then subject to nearby erosion. To recognize such redistribution where it has occurred and yet not to invoke this explanation to account for unexpected extensions of the life range of a species presents a serious problem requiring much critical attention.

The very marked difference between the large number of distinctive forms of the late Cretaceous (Maestrichtian) and those of the early Tertiary (including the Danian) is evident in many regions of Europe and America, in Egypt, Pakistan, and New Zealand (Bramlette, 1958). In southwestern France this marked difference is found with no admixture of the Maestrichtian forms in overlying Danian strata. Rare specimens of the abundant forms of the Upper Cretaceous appear in the Upper Paleocene and Lower Eocene (Ypresian or Cuisian) of this area, and a few occur in the lower Lutetian. As a result of the Middle Eocene deformation of the Pyrenees, however, a great abundance of Upper Cretaceous forms admixed with abundant specimens of many Paleocene and Lower Eocene species occurs in the late Middle Eocene and later strata of the region. The great number of reworked older specimens exceeds the many indigenous forms in the Upper Eocene of the Côte des Basques section at Biarritz, although they are much less common in equivalent strata at localities about 30 kilometers north of the Pyrenees. A nonmarine clay of Oligocene age in Provence, received from Deflandre, contains many specimens of Upper Cretaceous and early Tertiary forms (for locality see Deflandre, 1959, p. 133).

A comparable mixing of Cretaceous forms with those from various parts of the early Tertiary appears conspicuously in regions about the Alps in strata deposited after the mid-Tertiary deformation of the Alps. Obviously, any range chart from such a region which merely connects the earliest and latest occurrence of a species is meaningless if it does not indicate distribution in intermediate strata. Consideration of the relative abundance and conditions of preservation of specimens may assist in resolving problems of possible reworking. Data on distribution in many regions, however, are obviously necessary for interpreting the time range of a species; fortunately, the succession seems little affected by such reworking in many places. The possibility of redistribution nevertheless makes the earliest occurrence the most trustworthy part of the observed range in any interpretation of the actual life span of a species represented by such small fossil remains.

The Lodo section of California shows little evidence to suggest reworking of the material, except for rare specimens in the upper part of the Lower Eocene (Unit 3). The distributions shown in Table 1 indicate a re-

markably abrupt termination of the range of many of the common species of the Paleocene, so abrupt as to suggest some discontinuity. All the common and easily recognizable species of the Paleocene, however, have been found sporadically but only as very rare specimens in samples from the upper part of the Lower Eocene strata (Unit 3). The only exception is that some of the Braarudosphaeridae reappear in considerable numbers in the Lower Eocene and are also known in the Eocene of other regions. Although these rare specimens may represent a sparse survival into the Eocene of species common only in the Paleocene, available evidence seems to favor the interpretation that they were reworked from the Paleocene.

This problem, as related to the actual life span of these particular species, seems especially important because of the wide geographic distribution known for most of them. Examination of other areas in California and additional ones elsewhere seems necessary, but the following considerations appear to indicate some redistribution into the Lower Eocene. None of these forms reappears in appreciable numbers in the Lower Eocene strata here, and none of them is as yet known in the Eocene elsewhere except where they are evidently reworked into distinctly later strata, as in the area north of the Pyrenees. Some redistribution is also indicated by the fact that these forms were apparently derived from two distinct biostratigraphic units, some of them occurring in Unit 1 but not in the latest Paleocene (Unit 2), and others occurring in the latest Paleocene (Unit 2) but not in Unit 1 nor in the lowest Eocene. Some reworking of underlying material into the Lower Eocene might be expected because the Cantua Member occurs as a large sandstone lens in the Lower Eocene part of the Lodo Formation a few miles to the south, indicating some uplift or increased erosion. This is also suggested by the absence of Paleocene strata at the base of the Lodo Formation farther south, as reported by Laiming (1940, p. 557).

Pending final resolution of this problem in the Lodo section, the rare and sporadic Lower Eocene occurrences of forms apparently redistributed from the Paleocene are recorded as "(reworked?)" in the discussions of distribution under the systematic descriptions.

BIOSTRATIGRAPHIC ZONES

The species distributions recorded in Table 1 indicate six biostratigraphic units, numbered from Unit 1, at the base and thus with its lower limit undefined, up to Unit 6, with its upper limit not defined here. Although the other units (2–5) are locally well defined by the range relations of many species, their delimitation as biostratigraphic zones with a designated species name seems best deferred until the sequence is similarly delimited in more than one area. The later discussion of correlations and age assignments indicates, however, that these local biostratigraphic units may be related to zones in similar succession that can be recognized widely, although they are not yet adequately delimited in the other regions.

The indicated range of any taxon may have only very local significance, except for the few taxa that show phylogenetic lineages in the local succession. The kind of biostratigraphic zone considered here, however, is a range zone based on the overlaps in the ranges of a considerable number of the species. Few of them are apt to be restricted to the zone, and the zone is recognized primarily by the association of those species having their highest (latest) occurrence in the zone with some others having their lowest (earliest) occurrence in the zone. On the other hand, a large number of coincident range limits, such as between Units 2 and 3, suggests a discontinuity either in the depositional record or of facies. Certain of the six biostratigraphic units may justifiably receive provisional zonal names, at least for the convenience of present discussion. The taxon used for a zonal name, however, is only one of those whose range seems significant in delimiting the zone, and the range of this taxon need not correspond even locally with the limits of the zone. Such a zone is thus quite different from the particular taxon's biozone, which is defined by the range of that taxon alone. *Discoaster tribrachiatus* is common in Unit 3 and happens to be locally limited to it. Because the species occurs also in other regions in strata in which the range relations of associated species are very similar, the name *Discoaster tribrachiatus* Zone appears to be appropriate for more than local or provincial use. Delimitation of the zone elsewhere, however, would be based primarily on the relations of the ranges of all associated taxa, and the range of *D. tribrachiatus* could extend into earlier or later strata of adjacent zones.

The six biostratigraphic units based on the calcareous nannoplankton, with provisional zonal names used for some, seem to correspond rather closely with the foraminiferal zones of Laiming (1940) that have been in common use in California. However, the strata included here in Unit 3 have been subdivided into several of these local foraminiferal zones, whereas Units 5 and 6 are not separated by the foraminiferal evidence. The biostratigraphic units are markedly unequal in terms of stratal thickness, as might be expected from varying rates of accumulation, and Unit 3 includes most of the Lodo Formation.

Biostratigraphic Unit 1 is represented in Table 1 by only two samples from the basal Lodo, as samples below and immediately above are barren of these fossils. The lower limit therefore cannot be delimited in this local section, and its upper limit is poorly defined because the sequence is interrupted by additional barren strata. Among distinctive forms not occurring in the overlying Unit 2 and known in similar association elsewhere are *Heliolithus riedeli*, *Discoaster helianthus*, and *Zygolithus junctus*. *Coccolithus bidens* and *C. eminens* are only locally restricted to this zone, and elsewhere their range extends up into the later Paleocene (Unit 2 equivalents).

Other species of the zone, but with known occurrences here and elsewhere in earlier or later strata, are indicated in the systematic discussions of species, and some also in the later discussion of correlations and age assignments. Although not well delimited locally, this biostratigraphic unit is apparently recognizable in a similar zonal succession in widely separated regions, and the name *Heliolithus riedeli* Zone seems appropriate for provisional use in the discussion of correlations. It appears to correspond closely with the local foraminiferal Zone E of Laiming (1940).

Biostratigraphic Unit 2 is quite distinct from Unit 1, although much of the abrupt change is doubtless related to factors involved in the intervening barren strata in this section. *Discoaster multiradiatus* s. l. is a conspicuous element of Unit 2. The more delicate varietal form (pl. 12, fig. 11) is locally dominant, but the typical form is the common one in equivalent strata of nearby localities of California and in most other occurrences. Although *D. multiradiatus* occurs rarely (possibly as reworked specimens) in the overlying Unit 3, its abundant and very widespread occurrence in strata having species range relations similar to those in Unit 2 suggests that the name *Discoaster multiradiatus* Zone may be appropriate for such strata. Among species with ranges now appearing particularly significant in delimiting the zone elsewhere are *Zygodiscus sigmoides*, *Zygrhablithus simplex*, *Zygolithus distentus*, *Rhomboaster cuspis*, and *Coccolithites distichus*. These common forms seem to have their latest known occurrence in the Paleocene elsewhere but occur locally as very rare specimens in Unit 3, although, as has been indicated, they may represent some local redistribution from Unit 2. Not questionable because of possible reworking, however, are the earliest known occurrences of many forms, which include *Lophodolithus nascens*, *Coccolithites delus*, *Clathrolithus ellipticus*, *Discoaster mediosus*, and *D. multiradiatus*. Unit 2 corresponds closely to the foraminiferal Zone D of Laiming (1940).

Biostratigraphic Unit 3 includes the upper 1050 feet, or most of the Lodo Formation. The assemblage is much the same throughout except for a general decrease in abundance of most species in the upper part. The change in the assemblage from that of Unit 2 is so marked and abrupt that it appears to indicate some considerable discontinuity either in recorded time or in facies. No conspicuous physical discontinuity is apparent, but it is perhaps significant that much glauconite is concentrated here. Similar general relations in the ranges of the species of Units 2 and 3 are known in other regions, but continuous sequences in these regions would presumably show more gradual change with more overlaps in species ranges than occurs in the Lodo section. Some transitional aspect is indicated only in the lower 40 feet of Unit 3 (samples 23 to 36 or 37). Although the similarities support its inclusion in Unit 3, this basal part has a somewhat larger number of species in common with Unit 2 than occur in the higher strata of Unit 3. The name *Discoaster tribrachiatus* Zone seems appropriate for the strata included in biostratigraphic Unit 3 and its equivalents elsewhere, as the species is locally restricted to the unit, although this is of less importance than its wide distribution with the associated species indicated in the later discussion of correlations and age assignments. Among many species locally restricted to Unit 3, those that are apparently equally restricted elsewhere include *Chiphragmalithus calathus*, *Discoaster diastypus*, and *Rhabdosphaera truncata*. Developments in a lineage involving *Lophodolithus nascens* also seem very significant, as this widespread species is nearly restricted to this zone. Many species have their earliest known occurrence in this zone, such as the common and widespread *Coccolithus grandis*, *Discolithus pulcher*, *Helicosphaera seminulum*, *Rhabdosphaera crebra*, *R. perlonga*, *R. scabrosa*, *Zygolithus dubius*, and *Discoaster lodoensis*. The lower part of Unit 3 corresponds to the foraminiferal Zone C of Laiming (1940), and the upper part to his less clearly defined Zones B4, B3, and B2. However, these upper subdivisions, based largely on benthonic foraminifera, are not apparent from the nannoplankton of the strata included in biostratigraphic Unit 3.

Biostratigraphic Unit 4 is represented in the finer-grained beds within and at the top of the otherwise barren Domengine Sandstone. Only two representative samples were thoroughly examined and are recorded in Table 1. Unit 4, for which the name *Chiphragmalithus acanthodes* Zone may prove appropriate, seems to be recognizable as a zonal unit in regions as distant as Europe. Although this species is not known to occur in large numbers, it appears to be significant because of a lineage indicating that it gave rise to *C. cristatus* in immediately overlying strata. Many of the species of Unit 3 have their latest occurrence in Unit 4, and among those which seem significant because of known occurrences elsewhere are *Coccolithus crassus*, *Rhabdosphaera crebra*, *R. morionum*, *R. perlonga*, *Coccolithites gammation*, *Clathrolithus ellipticus*, and *Discoasteroides kuepperi*. Among distinctive ones with their earliest known occurrence in Unit 4 are *Coccolithus expansus*, *Discolithus distinctus*, *D. panarium*, *Lophodolithus mochlophorus*, *Rhabdosphaera tenuis*, *Chiphragmalithus acanthodes*, *C. cristatus*, *Discoaster basquensis*, *D. nonaradiatus*, and *D. sublodoensis*. Unit 4 corresponds to the local foraminiferal Zone B1 of Laiming (1940).

Biostratigraphic Unit 5 is represented in the lower part of the "Canoas Member" of the basal Kreyenhagen Formation in the Oil City section and in the basal few feet of the Canoas Member near the type area on Garza Creek. Only three samples representing the unit were thoroughly examined and are recorded in Table 1. Most of the species of Unit 4 range up into this unit, although generally in lesser numbers. Among those having their latest known occurrence in this biostratigraphic unit are *Discolithus distinctus*, *D. panarium*, *Lophodolithus mochlophorus*, *Coccolithites delus*, *Chiphragmalithus acanthodes*, and *Discoaster sublodoensis*. Distinctive species with their earliest known occurrence in Unit 5

include *Discolithus exilis*, *D. fimbriatus*, and *Rhabdosphaera inflata*. Although this unit may not represent a very well defined one in other regions, similar range relations of most of the species even as far away as France, are indicated.

Biostratigraphic Unit 6 is represented by all but the basal few feet of the type Canoas Member of the basal Kreyenhagen Formation and extends upward in the Kreyenhagen to an upper limit not defined by the samples available for this study. Only two samples from the lower part of this unit on Garza Creek are recorded in Table 1. Although this unit is distinct from Unit 5 in the central California region, this may be largely a facies difference, and Unit 6 is not well characterized here by the appearance of many new species, except perhaps some small and nondescript forms. Further study of Unit 6 is therefore deferred until a better characterized equivalent from a sequence elsewhere may be examined and compared with Unit 6. *Chiphragmalithus? quadratus* is a distinctive form with wide geographic distribution, which is common in Unit 6, although a few specimens occur also in the uppermost part of the underlying unit. It seems to be one of the species of Unit 6 whose range may prove particularly significant.

CORRELATIONS AND AGE ASSIGNMENTS

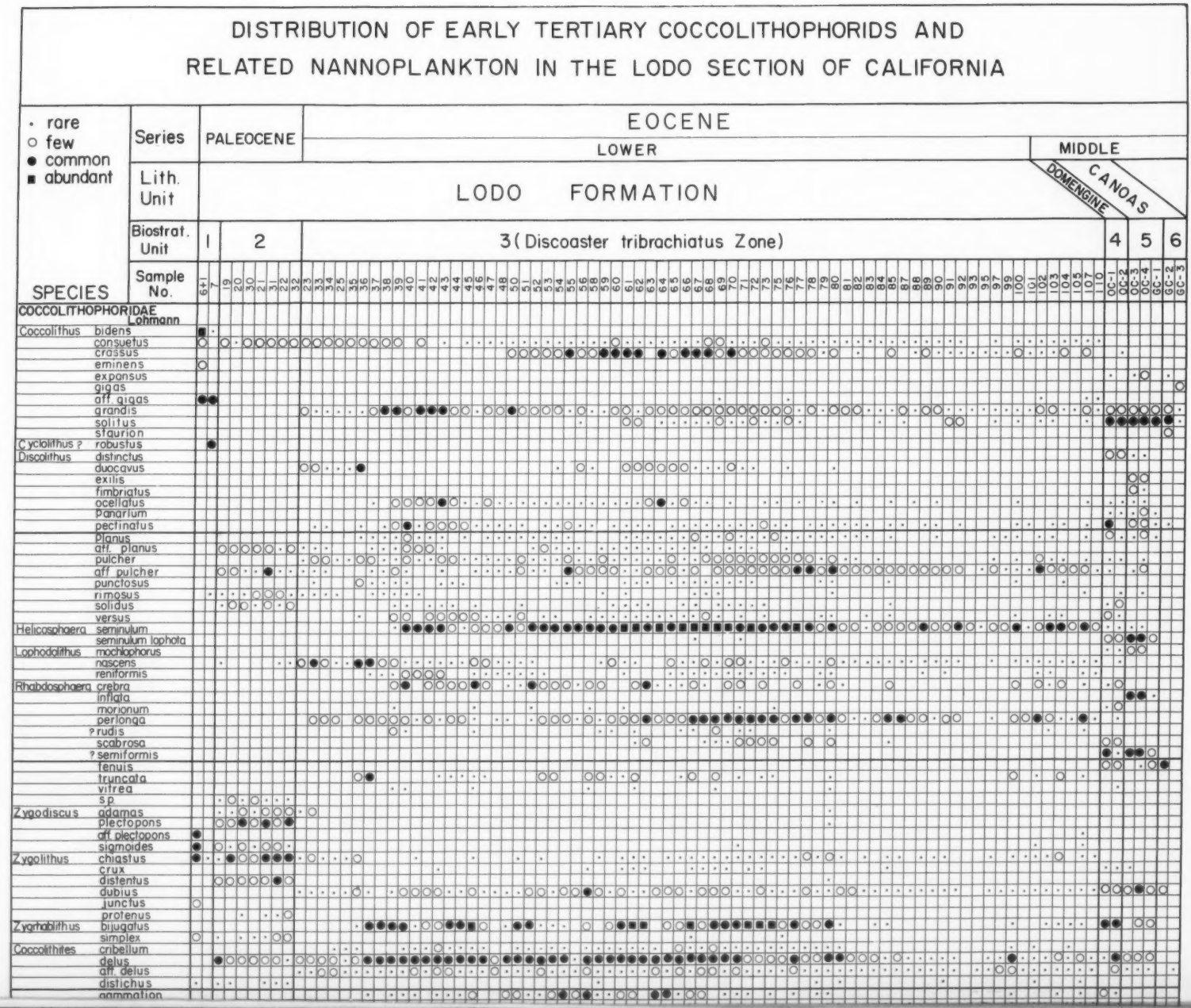
The very widespread occurrence of many species of the calcareous nannoplankton is now evident; it is especially striking in the Cretaceous and early Tertiary, reflecting, like that of other fossils, the relative uniformity of the seas of that time. A comparatively short life span is indicated for many of these species by considerable (though still inadequate) data on their ranges, including a zonal sequence that is recognizable in widely separated regions. Much of the evidence bearing on correlations and age assignments cannot be reviewed because many species are still undescribed, and no evaluation of evidence from other groups of fossils can be attempted here.

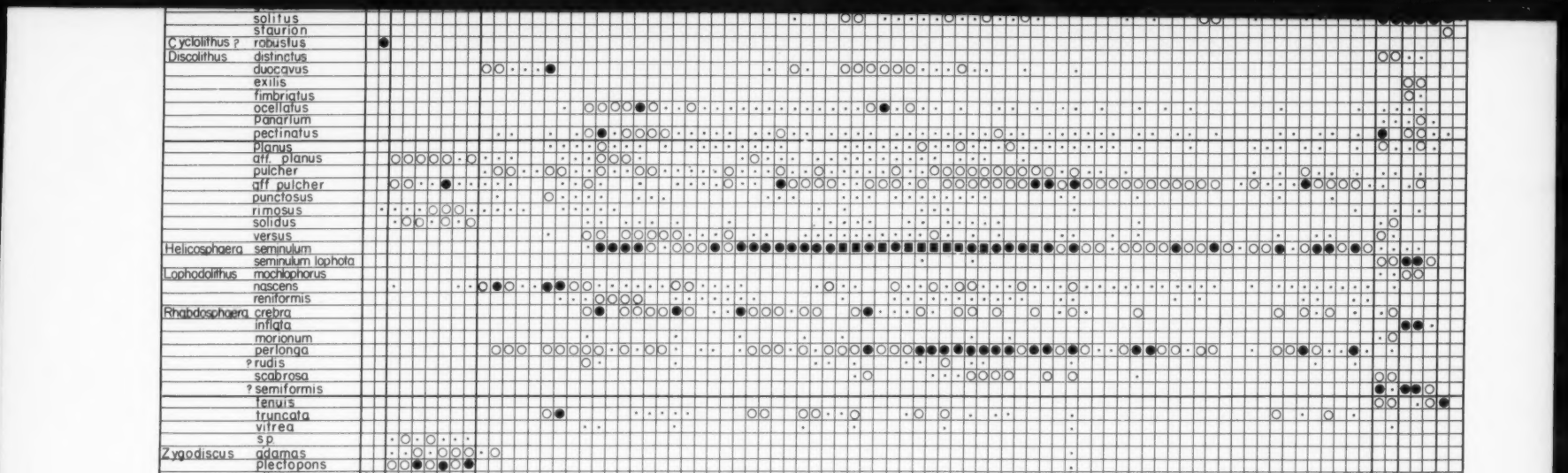
Recognition with some assurance of a general succession similar to that of the biostratigraphic units delimited in the Lodo section seems possible in some regions as distant as the type areas of European stages. Although upper and lower limits will probably never be precise for any zones of such wide extent, further study of additional continuous sequences is obviously needed. Such sequences are not exposed, however, at most type localities of European stages, and the stage limits have remained undefined. The following discussion summarizes the evidence for correlating the local biostratigraphic units with those of some other areas, particularly with those closely related to the succession of early Tertiary stages in Europe, which thus offers some support to the age assignments.

Unit 1 (provisionally referred to as the *Heliolithus riedeli* Zone) includes strata which have been considered of Paleocene age from studies of the foraminifera and other fossils. The following considerations support this age assignment and suggest correlation with that part of the Paleocene represented by the type Thanetian Stage in England. The Strata underlying Unit 1 of the Lodo section are barren of nannoplankton fossils, but these lower strata have been assigned a Maestrichtian age from other evidence, and an unconformity is indicated at the base of Unit 1. However, at Borreguero Spring, about 13 miles to the southeast, strata correlating well with biostratigraphic Unit 1 are immediately underlain by strata containing species having range relations similar to those of the type Danian. Few of the many and distinctive species of the Maestrichtian have ranges extending up into the Danian of any known region (Bramlette, 1958). Forms such as *Zygrhablithus simplex*, *Zygodiscus sigmoides*, and *Zygolithus chiastus* are common in the type Danian but extend up into the Paleocene of Europe and likewise into Unit 1. The distinctive *Heliolithus riedeli* and *Discoaster helianthus* of Unit 1 occur in the type Thanetian and are as yet unknown in European strata of earlier or later ages. Except for a few poorly preserved and obviously reworked Cretaceous coccoliths, the species of the meager assemblage of the type Thanetian are all represented in the larger assemblage of Unit 1, including those forms which range either higher or lower in both regions. *Heliolithus riedeli* and others indicative of the zone occur in the Velasco Shale of Mexico, overlying strata assigned to the Danian and underlying strata with *Discoaster multiradiatus* and other species of Unit 2 in like association. A similar sequence is found in the lower Lizard Springs strata of Trinidad, with the *Heliolithus riedeli* Zone occurring in the *Globorotalia pseudomenardii* foraminiferal zone of Bolli (1957). The Nanafalia Formation of Alabama also includes *H. riedeli* and other species of Unit 1 and of the Paleocene elsewhere. Although the Nanafalia is commonly assigned to the Lower Eocene, the nannoplankton species of the basal Eocene elsewhere appear only in the stratigraphically higher Bashi Formation of Alabama. Loeblich and Tappan (1957) also presented evidence for considering the Nanafalia Formation of Paleocene age, based on a study of the pelagic foraminifera, and this problem thus seems to deserve more consideration.

Unit 2 (the provisional *Discoaster multiradiatus* Zone) is well represented in the Upper Paleocene of many regions, and the following considerations suggest equivalence with the largely nonmarine Sparnacian Stage of Europe. Many species identical with those of Unit 2, and with similar range relations, occur in the upper part of the Paleocene strata of southwestern France. These strata overlie those of the *Heliolithus riedeli* Zone (included in the type Thanetian) and underlie Cuisian strata considered to be of approximately the same age as the Ypresian and other Lower Eocene strata. The *Discoaster multiradiatus* Zone in France thus occurs in a similar stratigraphic position to that of the Sparnacian, which is generally considered the upper stage of the Paleocene. Similarly, *D. multiradiatus* and some of the

DISTRIBUTION OF EARLY TERTIARY COCCOLITHOPHORIDS AND RELATED NANNOPLANKTON IN THE LODO SECTION OF CALIFORNIA




solitus
stgurion
Cyclolithus ? rabustus
Discolithus distinctus
duocavus
exilis
fimbriatus
ocellatus
Panarium
pectinatus
Planus
aff. planus
pulcher
aff pulcher
punctosus
rimosus
solidus
versus
Helicosphaera seminulum
seminulum lophota
Lophodolithus mochlophorus
nascens
reniformis
Rhabdosphaera crebra
inflata
morionum
perlonga
? rudis
scabrosa
? semiformis
tenuis
truncata
vitrea
sp.
Zygodiscus adamas
plectopons

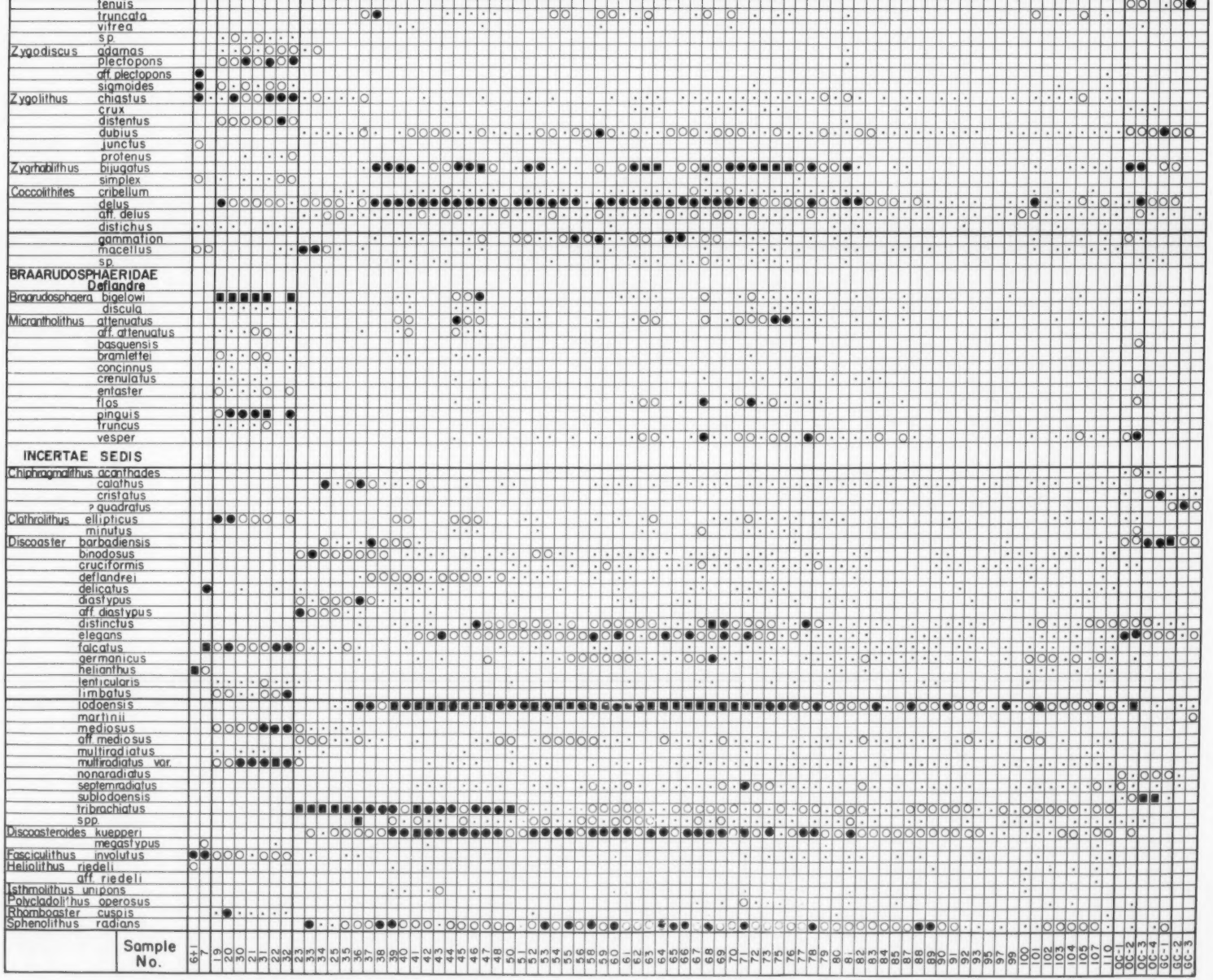

tenuis
truncata
vitrea
sp.
Zygodiscus adamas
plectopons
aff. plectopons
sigmoides
Zygolithus chiastus
crux
distentus
dubius
junctus
protenus
Zygorhablithus bijugatus
simplex
Coccolithites cribellum
delus
aff. delus
distichus
gammation
macellus
sp.
BRAARUDOSPHAERIDAE Deflandre
Braarudosphaera bigelowi
discula
Micrantholithus attenuatus
aff. attenuatus
basquensis
bramlettei
concinnus
crenulatus
entaster
flos
pinguis
truncus
vesper
INCERTAE SEDIS
Chiphragmalithus acanthodes
calathus
cristatus
? quadratus
Clathrolithus ellipticus
minutus
Discoaster barbadiensis
binodosus
cruciformis
deflandrei
delicatus
diastypus
aff. diastypus
distinctus
elegans
falcatus
germanicus
helianthus
lenticularis
limbatus
lodoensis
martinii
mediosus
aff. mediosus
multiradiatus
multiradiatus var.
nonaradiatus
septemradiatus
sublodoensis
tribrachiatus
spp.
Discoasteroides kuepperi
megastypus
Fasciculithus involutus
Heliolithus riedeli
aff. riedeli
Isthmolithus unipons
Polycladolithus operosus
Rhomboaster cuspis
Sphenolithus radians
Sample No.
6+1
7
19
20
30
21
31
22
32
23
33
34
25
35
36
37
38
39
40
41
42
43
44
45
46
47
48
50
51
52
53
54
55
56
58
59
60
61
62
63
64
65
66
67
68
69
70
71
72
73
75
76
77
78
79
80
81
82
83
84
85
87
88
89
90
91
92
93
95
97
99
100
101
102
103
104
105
107
110
OC-1
OC-2
OC-3
OC-4
GC-1
GC-2
GC-3

TABLE 1

associated species of Unit 2 occur in Trinidad in the *Globorotalia velascoensis* Zone of Bolli, which is underlain by strata here assigned to the *Heliolithus riedeli* Zone and is overlain by the *Globorotalia rex* Zone of Bolli, which he assigns to the basal Eocene. Similar relations with the *Heliolithus riedeli* Zone in the Velasco Shale of Mexico were mentioned in the discussion of Unit 1. The *Discoaster multiradiatus* Zone seems to be recognizable in the Waipawan Stage of New Zealand and in the Paleocene of Algeria, but relations with other zones are not known in those regions. Nearly all the species in the Bashi Formation of Alabama are found in the Lodo, where their range relations result in a similar association in the uppermost part of Unit 2. However, some similarity of the Bashi assemblage to that of the basal part of Unit 3 suggests a more transitional aspect than appears in the Lodo section, where some discontinuity is indicated by the sharply marked difference between biostratigraphic Units 2 and 3. The following discussion of Unit 3 indicates the basis for its assignment to the Lower Eocene, and the Bashi Formation might thus be assigned to either the uppermost Paleocene or the basal Eocene from available evidence of the calcareous plankton. Unfortunately, the strata immediately overlying the Bashi are barren of these fossils.

Unit 3 (the *Discoaster tribrachiatus* Zone) includes strata that apparently correlate well with some part, at least, of the Ypresian Stage. Although none of the nannoplankton has been found in samples from the type Ypresian, relations with other Lower Eocene strata in Europe are indicated. The London Clay, which is a well-established equivalent of the Ypresian, seems to include few of these fossils, but the occurrence in it of *Discoaster tribrachiatus* and *Chiphragmalithus calathus* seems significant, as these forms are restricted to Unit 3. The Rösnaes clay of Rögle Klint, Denmark, also considered to be Ypresian, contains many species, and those which occur also in the Lodo section include forms that characterize Unit 3 by their range relations. *Discoaster tribrachiatus* is abundantly represented in the Rösnaes clay, as is *Lophodolithus nascens*, a species which appears to be especially significant because of a lineage recognizable in the Lodo succession, where the range of this form corresponds approximately to the limits of Unit 3. *Discoaster lodoensis* is also common, although in Europe, as in the Lodo, it ranges upward into strata assigned to the Middle Eocene, as do some of the other species in the Rösnaes clay. In Trinidad, the *Discoaster trichbrachiatus* Zone seems to be well represented in the *Globorotalia aragonensis* foraminiferal zone of Bolli, which he too assigns to the Lower Eocene. The Bashi Formation of Alabama may include the basal part of the *Discoaster tribrachiatus* Zone, but its greater similarity to the uppermost Paleocene Unit 2 is indicated in the preceding discussion of that unit.

Unit 4 is represented locally only in the Domengine Formation, which has been assigned to the Middle Eocene on the basis of various studies of the Mollusca, foraminifera, and other fossils. A zone similar to that delimited as Unit 4 is recognizable in strata generally assigned to the Middle Eocene in some widely separated regions. Although species restricted to the zone are not yet known, it seems clearly recognizable by the distinctive association of many species which have their earliest or their latest occurrences in Unit 4. Correlation with the type Lutetian is unsatisfactory as the strata of that stage represent a shallow-water facies, and very few of these or other planktonic fossils are present. However, the very large assemblage present in samples from the Tuilerie of Donzacq, southwestern France, many of which were described by Deflandre (1954), is from strata commonly assigned to the lower Lutetian. This assemblage is remarkably similar to that of Unit 4, although their correlation seems justified only because of the large number of associated forms which have range overlaps characteristic of the zone. Among the many species common to the two areas, *Lophodolithus mochlophorus* is especially significant because of the lineage showing the development of this species from *L. nascens* in Unit 4 of the California sequence. Higher strata of Lutetian age in southwestern France are discussed under Unit 5. Samples from the lower part of the Weches Formation (Middle Eocene) of southeastern Texas also contain an association of species very much like that of Unit 4, which likewise includes *L. mochlophorus* among the more significant elements. At least a part of the Tallahatta Formation of Alabama is apparently assignable to this zone, although the samples that are available have a rather meager assemblage.

Unit 5 is represented locally in the "Canoas Member" of the Kreyenhagen Formation in the Oil City section, and also in the basal part of the type area of the Canoas Member, on Garza Creek. The occurrence of this biostratigraphic unit in the 20 feet of clay beneath the Kreyenhagen Formation and overlying the "Avenal" Sandstone in Coal Mine Canyon, about 8 miles south of Oil City, is significant in connection with an interesting problem of local correlation. The basal one foot of this clay unit above the "Avenal" Sandstone can be assigned to Unit 4, but the remaining 19 feet, below a glauconite bed, seem to be clearly equivalent to Unit 5 in the "Canoas" overlying the Domengine Formation at Oil City. Unit 5 may not prove as well characterized as the underlying units for extension as a zone elsewhere, although strata of the middle Lutetian at Gibret in southwestern France have a surprisingly similar association of species. Among those in samples from Gibret now appearing particularly significant are abundant specimens of *Discoaster sublodoensis* and the peculiar and apparently quite restricted form *Rhabdosphaera inflata*. The upper part of the Weches Formation (Middle Eocene) in southeastern Texas appears to be equivalent to Unit 5, but available samples do not include a very large number of species.

Unit 6 was indicated in the preceding definitions of units as still inadequately characterized, and the upper

limit has not yet been determined. Although it may prove to be of Upper Eocene age, the little evidence now available from this study suggests that it too should be included in the Middle Eocene.

TAXONOMIC PROBLEMS

Classification of most groups of the living nannoplankton is especially difficult, as reflected by the common use of the term Protista for many of them. The living coccolithophorids, which form the most important group of nannoplankton with calcareous skeletal elements, are usually classed with the unicellular algae because they photosynthesize food. However, they not only have a flagellate motile form, but Parke and Adams (1960) have observed ingestion and assimilation of foreign food particles (phagotrophy) among typical coccolithophorids. Their observations thus support the grouping as protists, and since the nomenclature of zoology rather than botany has commonly been applied, such usage is followed here.

Advantageously for paleontology, the classification of living coccolithophorids has been based largely on the calcareous skeletal elements (various forms of coccoliths, rhabdoliths, etc.). However, attempts at a natural classification remain very unsatisfactory. Details of form and microstructure of the coccoliths obtained from studies with the electron microscope are proving important in nomenclature, but cultures (Parke and Adams, 1960) indicate complications in at least one species, owing to the alternation of generations having quite different forms of coccoliths for the single species. Some living species also have skeletal elements surrounding the oral opening which are quite different from the rest of the coccoliths on the coccosphere, and these two forms of coccoliths are normally dissociated after the death and disintegration of the organism. The usual difficulties encountered in classifying fossil forms with little similarity to modern species are thus increased.

An artificial classification based on morphologic similarities characterizing form-genera and species thus seems necessary at this time and may prove serviceable in biostratigraphy. Even though two form-species may prove to represent only a single species having two different skeletal elements, this finding would not alter stratigraphic interpretations based on records of their distribution in space and time. This distribution, by indicating consistently associated forms and their numerical ratio, might afford some evidence for recognizing dimorphous coccoliths from one species. Although many form- or parataxa seem necessary, two groups (*Coccolithus* and *Rhabdosphaera*) of the fossil species may be assigned to living genera, with at least as much assurance as with most fossils. These two genera, defined by the distinctive character of skeletal parts of the living species, are therefore recognized here, but they are also rather artificial taxa at present, and the precise and marked distinction of parataxa from the usual taxa as applied in paleontology may not be particularly significant. This more objective but quite artificial classification does not seem to justify elaborate grouping into hierarchies, which is therefore not followed here to any great extent.

Two major groups, classed as the orders Heliolithae and Ortholithae by Deflandre (1950), suggest a useful subdivision, although the distinguishing character is not applicable to some genera, and the phylogenetic significance is not yet apparent. The Heliolithae include forms composed of many fibrous elements or crystallites in more or less radial arrangement, as is usual in the coccolithophorids proper, and the Ortholithae include forms composed of a single calcite crystal, or crystals of like orientation, as in *Discoaster* and many other genera *incertae sedis*. This difference in microstructure is evidently important and is an obvious one, despite certain forms in which these characters are combined. The heliolithid character (as in the new genus *Heliolithus*) or the ortholithid character is emphasized here, but genera are not here assigned to these formal orders.

Kamptner (1958) made the most recent attempt to classify the calcareous nannoplankton, applying form-genus names to fossil groups of doubtful relation to living genera. Deflandre (1952*b*) followed a somewhat similar classification; in Deflandre and Fert (1954), he described a number of new paragenera and genera *incertae sedis*. Their generic usage is followed here in large part but without Kamptner's elaboration of family, subfamily, tribe, and subtribe groupings. All the coccolithophorids proper are included here, as by Lohmann (1902), in his family Coccolithophoridae. The latter, however, includes groups that may raise it to a higher taxonomic level than Deflandre's family Braarudosphaeridae, which is the only other family name used here. The many remaining forms are unassigned other than to genera *incertae sedis*.

SYSTEMATIC DESCRIPTIONS

Family Coccolithophoridae Lohmann

Genus Coccolithus Schwarz, 1894

An inadequately defined genus commonly used for coccoliths consisting of two elliptical plates joined rather closely by a hollow stud or tube, with the opening continuous through tube and plates. Distal plate larger than proximal one; both curved, with their concave surfaces on the proximal side.

This genus is well represented in the modern plankton by such species as *Coccolithus pelagicus*. Coccoliths of this type have been termed placoliths, and some of the fossil forms have been assigned to the paragenus *Tremalithus* (Kamptner, 1948). A special form-genus seems unnecessary, however, as coccoliths of this form are the main basis for characterizing the living genus *Coccolithus*. Assignment of the isolated fossil coccoliths to the paragenus *Tremalithus* until the complete coccosphere has been observed seems equally unnecessary, as the

considerable number of modern and fossil species now recognized show little of the dimorphism of coccoliths on individual coccospheres found in some other genera.

Coccolithus bidens Bramlette and Sullivan, **new species**
Plate 1, figure 1

Description: Distal plate of the coccoliths (placoliths) with a steep, slightly concave outer slope and a slightly wider, smooth inner slope. Small tooth-like projections into the central opening are vague or absent in the long axis but present though not prominent in the short axis. Central opening transversely spanned by a robust x-shaped structure consisting of one straight and one sigmoid bar. Length 6–13μ, usually about 10μ.

Remarks: This species is similar to *Coccolithus grandis* except in the much smaller size of the coccoliths and the vagueness of the tooth-like projections, though two of them are apparent, especially between crossed nicols. Similarities and range relations indicate that *C. grandis* developed from this small form.

Holotype: U.S.N.M. 564177, Lodo 6+1.

Distribution: Locally abundant in Unit 1 (Paleocene). Occurs in the Paleocene of many regions, including the Nanafalia Formation of Alabama, the type Thanetian of England, and 2.95 km. south of Gan, France.

Coccolithus consuetus Bramlette and Sullivan, **new species**
Plate 1, figure 2a–c

Description: Coccoliths (placoliths) with two plates closely appressed, the larger normally showing clearly the straight-radiating striae on the wide, convex outer slope. Inner slope narrow; small central opening transversely spanned by an x-shaped structure. Length 8–16μ, usually about 14μ.

Remarks: Placoliths of this species may be distinguished from those of the several other species of *Coccolithus* with a central x-shaped structure by the wide, convex outer slope, narrow inner slope, and relatively small central opening.

Holotype: U.S.N.M. 564178, Lodo 73.

Distribution: Locally present throughout Units 1, 2, and 3 (Paleocene to Lower Eocene). Occurs in the Weches Formation (Middle Eocene) of Sabine River, Texas, and in the Paleocene 2.95 km. south of Gan, France.

Coccolithus crassus Bramlette and Sullivan, **new species**
Plate 1, figure 4a–d

Description: Coccoliths (placoliths) subelliptical to elliptical and high, with plates not closely appressed; the larger plate thin and indistinct between crossed nicols but showing straight-radiating striae in transmitted light, commonly marked enough to appear as small petals. Connecting tube robust and conspicuous. Central opening small. Length 10–13μ.

Remarks: These placoliths differ from many rather similar but less distinctive undescribed forms of this genus in that the thinness of the upper plate contrasts strongly with the heavy connecting tube. The two plates are less closely appressed than in most described species.

Holotype: U.S.N.M. 564179, Lodo 71.

Distribution: Locally common in the middle part of Unit 3 (Lower Eocene) and extending upward in lesser numbers into Unit 4 (Middle Eocene). Occurs in the lower Lutetian (Middle Eocene) of Donzacq, France.

Coccolithus eminens Bramlette and Sullivan, **new species**
Plate 1, figure 3a–d

Description: Coccoliths (placoliths) subelliptical or nearly circular and very high, with the two plates very closely appressed and cupped together so that the smaller is barely visible in side view. The steep, concave outer slope of the larger plate usually shows striae running to the periphery. Small central opening spanned by cross bars, the transverse one of which is the more conspicuous. Length 9–11μ.

Remarks: This small, almost circular form differs from most other members of the genus studied here in its unusual height and in having its small central opening occupied by cross bars aligned with the axes of the ellipse.

Holotype: U.S.N.M. 564180, Lodo 6+1.

Distribution: Locally present in Unit 1 (Paleocene). Occurs in the Nanafalia Formation (Paleocene) of Alabama, in the type Thanetian of England, and in the Paleocene 2.95 km. south of Gan, France.

Coccolithus expansus Bramlette and Sullivan, **new species**
Plate 1, figure 5a–d

Description: Coccoliths (placoliths) large, with closely appressed plates. Both outer and inner slopes of the upper plate narrow, the outer slope steep and slightly concave. Relatively large central opening transversely spanned by a wide, arching x-shaped structure. Length 15–23μ.

Remarks: These placoliths are distinctive in their large central opening as contrasted with the narrow surrounding rim. They differ from those of *Coccolithus oamaruensis* (Deflandre) (Deflandre and Fert, 1954,

p. 154) in having a more widely spread x-shaped structure with curved bars, and in the larger proportion of the central opening.

Holotype: U.S.N.M. 564181, Canoas OC–4.

Distribution: Locally present in Units 4, 5, and 6 (Middle Eocene). Occurs in the Weches Formation (Middle Eocene) of Sabine River, Texas, and in the lower Lutetian (Middle Eocene) of Donzacq, France.

Cococlithus gigas Bramlette and Sullivan, new species
Plate 1, figure 6a–d

Description: Coccoliths (placoliths) unusually large, with closely appressed plates, the larger of which shows fine radiating striae on its wide, convex outer slope, which have a slightly sigmoid curvature, sinistral at the periphery in distal view. These striae extend onto the outer part of the inner slope, which is relatively narrow. Central opening transversely spanned by an x-shaped structure. Length 19–27μ.

Remarks: The placoliths of this species differ from those of *Coccolithus consuetus* in their much larger size, in the fineness and somewhat sigmoid curvature of the radiating striae, and in having fine "teeth" along the margin of the inner slope. They are larger than other species here included in the genus.

Holotype: U.S.N.M. 564182, Canoas GC–3.

Distribution: Locally present in Unit 6 (Middle Eocene).

Coccolithus aff. C. gigas Bramlette and Sullivan
Plate 1, figure 7a–d

Remarks: This form occurs in only the two lowermost samples, and as it does not differ greatly from *Coccolithus gigas*, a distinct taxonomic unit is not proposed here. Differences from the typical species and from the somewhat similar *C. consuetus* include the obscurity of the striae on the distal plate, which is also more delicate and shows little relief in contrast to the heavy connecting tube; many specimens show the x-shaped structure broken out, suggesting a delicate attachment. It also differs in size, being intermediate between the other two forms. The rather variable radial lines that mark the outer part of the inner slope are similar to those in *C. gigas*, although they are fewer in number and tend to extend farther inward toward the central opening. However, these differences may be due, at least in part, to localized conditions of less available calcium carbonate in the surface waters, as many other forms in these two samples also appear abnormally delicate.

Hypotype: U.S.N.M. 564183, Lodo 7.

Distribution: Locally common in Unit 1 (Paleocene), with very rare and sporadic occurrences in the upper part of Unit 3 (Lower Eocene). Occurs in the Paleocene 2.95 km. south of Gan, France.

Coccolithus grandis Bramlette and Riedel
Plate 2, figures 1a–b, 2a–c, 3

"Coccolith," JUKES-BROWNE AND HARRISON, 1892, Quart. Jour. Geol. Soc., vol. 48, p. 178, text-fig. 7.

Coccolithus cretaceus Archangelsky. – DEFLANDRE, 1952, Traité de Zoologie (ed. P. P. Grassé), vol. 1, fasc. 1, p. 463, text-fig. 360d.

Coccolithus grandis BRAMLETTE AND RIEDEL, 1954, Jour. Pal., vol. 28, no. 4, pp. 391–392, pl. 38, fig. 1a–b. – DEFLANDRE, 1954, *in* DEFLANDRE AND FERT, Ann. Pal., vol. 40, p. 152, text-fig. 48.

Remarks: Material from the type locality has been restudied. The original description fails to indicate the distinctive, small tooth-like projections that extend into the central opening between the bars of the wide x-shaped structure. The side view of the holotype shows less height than the average and distinctly less than that of the Lodo specimens; it also fails to show the steep, concave outer slope of the upper plate. The Lodo specimens range in length from 13 to 27μ, usually about 17μ.

Hypotypes: U.S.N.M. 564184–85, Lodo 67; and 564186, Lodo 80.

Distribution: Locally common throughout Units 3–6 (Lower and Middle Eocene). Common and very widespread in the Lower and Middle Eocene. The many occurrences include the Weches Formation (Middle Eocene) of Sabine River, Texas, and the lower Lutetian (Middle Eocene) of Donzacq, France.

Coccolithus solitus Bramlette and Sullivan, new species
Plate 2, figure 4a–c

Description: Coccoliths (placoliths) with closely appressed plates, the larger having a steep, slightly concave outer slope and a slightly wider inner slope. Diameter of inner slope approximately equal to that of the lower plate, so that in transmitted light the placolith appears rather similar on both sides. Relatively large central opening transversely spanned by a somewhat delicate x-shaped structure. Length 9–13μ.

Remarks: These placoliths are distinguished from those of *Coccolithus bidens* of similar size by the lack of tooth-like projections into the central opening and by the more delicate x-shaped structure. Although they are easily distinguished from *C. consuetus* in the Lodo strata by the narrower outer slope without apparent striae, this distinction may be more difficult to observe elsewhere.

Holotype: U.S.N.M. 564187, Lodo 62.

Distribution: Locally present in the upper part of Unit 3 (Lower Eocene) and common in Units 4, 5, and 6

(Middle Eocene). Common in the Weches Formation (Middle Eocene) of Sabine River, Texas.

Coccolithus staurion Bramlette and Sullivan, **new species**
Plate 2, figures 5a–b, 6a–c

Description: Coccoliths (placoliths) large, with closely appressed plates, the larger distal one having conspicuous straight-radiating striae on the wide outer slope. Central opening small, with a small cross, obscure in some specimens, aligned in the axes of the ellipse. Length usually 12–15μ.

Remarks: This species is distinguished from the many forms of rather similar character by its large size and very small central cross, and from the even larger *Coccolithus eopelagicus* (Bramlette and Riedel) primarily by having a central cross. The hypotype (pl. 2, fig. 5a–b) is from the Weches Formation, which has better preserved specimens than our California samples.

Holotype: U.S.N.M. 564188, Canoas GC–2.

Hypotype: U.S.N.M. 564189, Weches Formation, Sabine River, Texas (Feray sample T.U. 245).

Distribution: Locally present in Unit 6 (Middle Eocene). Common in the Weches Formation (Middle Eocene) of Sabine River, Texas, and at Gibret, France (Middle Eocene).

Genus **Cyclolithus** Kamptner, 1948

An inadequately defined genus generally used for coccoliths formed as a single ring with a large central opening. The genus may be represented by several species in our samples, but the small size of most, together with their nondescript character, makes recognition difficult and questionable. Electron microscope examination seems necessary for such forms, which are therefore neither described nor otherwise recorded here, except for an unusual form that is questionably assigned to the genus.

Cyclolithus? robustus Bramlette and Sullivan, **new species**
Plate 2, figure 7a–c

Description: Specimens large, circular, forming a thick ring, one side of which shows oblique striae. Ring grooved so as to resemble two closely appressed rings in side view. Open central area large and bordered by a narrow inner rim. Diameter 9–15μ.

Remarks: The large size and especially heavy or robust ring are distinctive features of the species but make the assignment to the genus *Cyclolithus* questionable.

Holotype: U.S.N.M. 564190, Lodo 7.

Distribution: Locally common in Unit 1 (Paleocene).

Genus **Discolithus** Kamptner, 1948

An inadequately defined genus commonly used for coccoliths consisting of a single elliptical plate, generally somewhat curved, with the proximal side concave and either with or without a marginal rim on the distal side.

The many California species assigned to this genus show a sinistral curvature of the extinction lines when viewed from the distal side between crossed nicols. The full interpretation and significance of this phenomenon must await electron microscope study, and it is not included in the generic characterization. The opposite curvature of the extinction lines is shown only on the outer flange of *Discolithus fimbriatus*, but this is the only species recorded here in the group with such a flange extending out from the rim.

Discolithus distinctus Bramlette and Sullivan, **new species**
Plate 2, figures 8a–b, 9a–c

Description: Discoliths with a high, very thick rim, but thickness varies greatly. Heavy basal plate about half as thick as the height of the rim and much reduced in area in specimens with a thicker rim. Basal plate irregularly perforated by conspicuous pores and with a longitudinal line, which is interrupted in the middle. Length 12–16μ.

Remarks: This unusually robust form is easily distinguished, despite marked variations, by its very heavy rim and basal plate and its conspicuously perforated central area. The appearance between crossed nicols is also distinctive, with the thickness producing birefringence in yellow and red and up to green in the thicker rim area.

Holotype: U.S.N.M. 564191, Domengine OC–1.

Paratype: U.S.N.M. 564192, Domengine OC–2.

Distribution: Locally present in Units 4 and 5 (Middle Eocene) but more common in Unit 4. Occurs in the Weches Formation (Middle Eocene) of Sabine River, Texas, in the Middle Eocene of Trinidad, in the lower Lutetian (Middle Eocene) of Donzacq, France, and in the somewhat later Middle Eocene of the Carriere de Nousse, France.

Discolithus duocavus Bramlette and Sullivan, **new species**
Plate 2, figure 11a–d

Description: Discoliths with a low, thin rim and a thin basal plate having two widely separated circular openings at the ends of a longitudinal line. Length 10–13μ.

Remarks: The widely separated circular openings in the basal plate of this relatively simple form characterize the species.

Holotype: U.S.N.M. 564193, Lodo 36.

Distribution: Locally present in Unit 3 (Lower Eocene).

Discolithus exilis Bramlette and Sullivan, new species
Plate 2, figure 10a–c

Description: Discoliths with a thin rim and two very large openings, leaving little of the basal plate other than a narrow transverse part. This bridge widens at opposite sides near the rim. Length 13–15μ.

Remarks: This species differs from *Discolithus* aff. *pulcher* Deflandre in having larger discoliths with larger openings and a somewhat sigmoid transverse bridge, and in the absence of even vague furrows on the rim.

Holotype: U.S.N.M. 564194, Canoas OC–4.

Distribution: Locally present in Unit 5 (Middle Eocene). Occurs in the Cane River Formation (Middle Eocene) of Louisiana.

Discolithus fimbriatus Bramlette and Sullivan, new species
Plate 3, figure 1a–d

Description: Discoliths with a high, thin rim with numerous vertical furrows or slits and a wide but thin striated flange extending outward from the top of the rim. Basal plate thin and pierced by two circular openings. Length 15–16μ.

Remarks: Except for the rim, this form is indistinct in Canada balsam, the wide, thin flange and the basal plate with its central openings being difficult to see except between crossed nicols. It differs from *Discolithus panarium* in the presence of the flange and in the longer slits in the rim.

Holotype: U.S.N.M. 564195, Canoas OC–4.

Distribution: Locally present in Unit 5 (Middle Eocene). Occurs in the Weches Formation (Middle Eocene) of Sabine River, Texas.

Discolithus ocellatus Bramlette and Sullivan, new species
Plate 3, figure 2a–c

Description: Discoliths consisting of a thick plate without rim but thinning slightly toward the center. Central area with two small openings and bisected by a longitudinal line ending near the periphery. Length 9–12μ.

Remarks: The discoliths of this species are nearly complanate but have some thickening of the margin rather than a distinct rim. The strong relief in Canada balsam and the birefringence up to red indicate the thickness of the plate shown in side view.

Holotype: U.S.N.M. 564196, Lodo 67.

Distribution: Locally present in Units 3, 4, and 5 (Lower and Middle Eocene).

Discolithus panarium Deflandre
Plate 3, figure 3a–d

Discolithus panarium DEFLANDRE, 1954, *in* DEFLANDRE AND FERT, Ann. Pal., vol. 40, p. 141, text-figs. 39–40.

Remarks: The Lodo specimens appear indistinct in Canada balsam except for the rim, as do the topotype specimens examined. The rim is thin but well defined, with a row of small perforations at its base. The thin basal plate normally has two circular openings, difficult to see except between crossed nicols, with a longitudinal line between them. The perforations and two larger openings are usually not as well developed in the topotype specimens, and the two larger openings are not mentioned in Deflandre's description. The Lodo specimens, however, seem to be properly included in his species. Specimens were found ranging in length from 11 to 19μ.

Hypotype: U.S.N.M. 564197, Canoas OC–4.

Distribution: Locally present in Units 4 and 5 (Middle Eocene). Occurs in the Weches Formation (Middle Eocene) of Sabine River, Texas; recorded from the lower Lutetian (Middle Eocene) of Donzacq, France.

Discolithus pectinatus Bramlette and Sullivan, new species
Plate 3, figures 4a–b, 5a–b

Description: Discoliths with a thin rim pierced by about 25 narrow vertical slits. Basal plate thin and bisected by a longitudinal line, interrupted toward the middle by two small circular openings. Length 9–13μ.

Remarks: As in *Discolithus pulcher*, the side view of this form clearly shows the vertical slits in the rim. It is distinct from *D. pulcher*, however, in that the central openings are circular rather than semicircular, it is smaller with more of the basal plate present, and the basal plate is bisected by a longitudinal line. Variants of *D. pectinatus* with shorter slits in the rim (pl. 3, fig. 5a–b) differ from *D. panarium*, which has the openings confined to the junction of rim and plate. *D. panarium* is also larger and appears vague in a Canada balsam mount except for the rim.

Holotype: U.S.N.M. 564198, Lodo 67.

Paratype: U.S.N.M. 564199, Lodo 80.

Distribution: Locally present in Units 3–6 (Lower and Middle Eocene). Occurs in the Weches Formation (Middle Eocene) of Sabine River, Texas.

Discolithus planus Bramlette and Sullivan, **new species**
Plate 3, figure 7a–c

Description: Discoliths consisting of a thick plate without rim, thinning only slightly toward the center. Central area smooth, bisected by a longitudinal line which is indistinct in the middle part. Length 7–11μ.

Remarks: This is another of the simple forms with nearly uniform thickness of the plate and without a rim. It differs from *Discolithus ocellatus* in not having the two openings in the plate.

Holotype: U.S.N.M. 564200, Lodo 70.

Distribution: Locally rare throughout Units 3, 4, and 5 (Lower and Middle Eocene). Occurs in the Weches Formation (Middle Eocene) of Sabine River, Texas, and in the lower Lutetian (Middle Eocene) of Donzacq, France.

Discolithus aff. **D. planus** Bramlette and Sullivan
Plate 3, figure 6a–b

Remarks: This very thin form is difficult to distinguish from especially thin specimens of the normally thick *Discolithus planus*. The typical form is absent, however, from the lower part of the section, where this thin form is most common. Recording it separately as *D.* aff. *planus* permits a provisional distinction, although this form may prove to be only locally significant.

Hypotype: U.S.N.M. 564201, Lodo 32.

Distribution: Locally common in Unit 2 (Paleocene) and rare in Unit 3 (Lower Eocene). Occurs in the Bashi Formation (Paleocene or Lower Eocene) of Alabama.

Discolithus pulcher Deflandre
Plate 3, figure 8a–c

Discolithus pulcher DEFLANDRE, 1954, in DEFLANDRE AND FERT, Ann. Pal., vol. 40, p. 142, pl. 12, figs. 17–18.

Remarks: The California specimens appear identical with topotypes of the species. The species typically has a rim with distinct vertical slits and a basal plate with two semicircular openings, leaving a narrow bridge-like transverse portion between them.

Hypotype: U.S.N.M. 564202, Lodo 36.

Distribution: Locally present in Units 3, 4, and 5 (Lower and Middle Eocene). Recorded from the lower Lutetian (Middle Eocene) of Donzacq, France.

Discolithus aff. **D. pulcher** Deflandre
Plate 3, figures 9a–b, 10

Remarks: This form with only vague or no slits or furfows in the rim grades into those with well-developed slits like the typical species. The transverse central part of the basal plate, however, is usually more oblique than in the typical species, and this form appears somewhat lower in the Lodo section.

Hypotypes: U.S.N.M. 564203–04, Lodo 67.

Distribution: Locally present throughout Units 2–5 (Paleocene to Middle Eocene). Occurs in the Weches Formation (Middle Eocene) of Sabine River, Texas, and in the lower Lutetian (Middle Eocene) of Donzacq, France.

Discolithus punctosus Bramlette and Sullivan, **new species**
Plate 3, figure 11a–c

Description: Discoliths consisting of a plate without rim but thinning slightly toward the center and irregularly perforated by many pores. Central area bisected by a longitudinal line, interrupted toward the middle by two openings only slightly larger than the pores. Length 9–11μ.

Remarks: The discoliths of this species are distinct in being nearly uniform in thickness, without the rim and thin basal plate common in the genus, and in having perforations over an unusually large part of the surface.

Holotype: U.S.N.M. 564205, Lodo 36.

Distribution: Locally rare in Unit 3 (Lower Eocene).

Discolithus rimosus Bramlette and Sullivan, **new species**
Plate 3, figures 12a–c, 13

Description: Discoliths consisting of a very thick plate, with thickness up to about one-half the length. Distinct rim lacking, but, plate thins toward the longitudinally elongate, irregular central opening, which varies greatly in width. Distal surface commonly shows irregular depressions extending into the central opening. Length 9–12μ.

Remarks: This species is distinct in the strong relief in Canada balsam due to its thickness and the orientation of the calcite crystallites, and also in the single, irregular, elongate central opening.

Holotype: U.S.N.M. 564206, Lodo 19.

Paratype: U.S.N.M. 564207, Lodo 22.

Distribution: Locally present in Units 1 and 2 (Paleocene), with rare occurrences in Units 3, 4, and 5 (Lower and Middle Eocene). Occurs in the lower Lutetian (Middle Eocene) of Donzacq, France, and in the Paleocene 2.95 km. south of Gan, France.

Discolithus solidus Deflandre
Plate 3, figures 14a–c, 15

Discolithus solidus DEFLANDRE, 1954, *in* DEFLANDRE AND FERT, Ann. Pal., vol. 40, p. 141, pl. 12, figs. 14–16.

Remarks: These very small but thick forms appear identical with topotype specimens. A short spike in the middle of the distal side is commonly present, and more

depression around the six small holes is evident on this side (pl. 3, fig. 14a). Other characters of this small species are difficult to determine, but the strong relief in Canada balsam also aids in specific identification. Retention in the genus *Discolithus*, however, is only provisional.

Hypotypes: U.S.N.M. 564208, Lodo 67, and 564209, Domengine OC–2.

Distribution: Locally present throughout Units 2, 3, and 4 (Paleocene to Middle Eocene). Occurs in the Weches Formation (Middle Eocene) of Sabine River, Texas; recorded from the lower Lutetian (Middle Eocene) of Donzacq, France.

Discolithus versus Bramlette and Sullivan, **new species**

Plate 3, figure 16a–d

Description: Discoliths with a low rim and thin basal plate, bisected by a longitudinal line, which is indistinct toward the middle. Length 8–12μ.

Remarks: The distinct rim is the only obvious difference between this species and *Discolithus planus*.

Holotype: U.S.N.M. 564210, Lodo 67.

Distribution: Locally present in Units 3 and 4 (Lower and Middle Eocene). Occurs in the lower Lutetian (Middle Eocene) of Donzacq, France.

Genus **Helicosphaera** Kamptner, 1954

This hitherto monotypic genus was originally characterized by coccoliths having two asymmetrical plates appearing as a helicoid form, with a bridge across the central opening.

Coccoliths here assigned provisionally to the genus show little of the helicoid form indicated by Kamptner (1954, pp. 21–23) for *Helicosphaera carteri*. However, our examination of that living species showed such a helicoid form only in an overlap on the larger (distal) plate, and revealed similarities to the Eocene form *H. seminulum* discussed below. Several species apparently intermediate in character and in age need further study for proper generic assignment and may reveal a phylogenetic sequence.

Helicosphaera seminulum Bramlette and Sullivan, **new species**

Description: Coccoliths consisting of two curved plates, both concave on the proximal side and somewhat asymmetrical in plan view, the distal plate larger. The two plates are closely joined at the small end and partly along one side but are distinctly separated at the large end. Small central opening spanned by a thick bar. Length 10–15μ.

Remarks: As mentioned in the discussion of this genus, the helicoid form is not evident in this species, but it seems less pronounced in *Helicosphaera carteri* than indicated by Kamptner (1954, pp. 21–23). Similarities in the two species include the same asymmetry in side view due to the plates being closely joined at their small end, and the arrangement of the crystallite components appear the same between crossed nicols.

Helicosphaera seminulum seminulum Bramlette and Sullivan, **new subspecies**

Plate 4, figures 1a–c, 2

Description: This subspecies has the oblique bar more nearly parallel to the transverse than the longitudinal axis. Length 10–13μ.

Remarks: The bar is usually more oblique to the transverse axis in specimens from the upper part of the Lodo section, and thus seems gradational into the later subspecies.

Holotype: U.S.N.M. 564211, Lodo 67.

Paratype: U.S.N.M. 564212, Lodo 67.

Distribution: Locally common through most of Unit 3 (Lower Eocene) and rare in Units 4 and 5 (Middle Eocene). Common in the Lower and Middle Eocene of many regions, including the lower Lutetian (Middle Eocene) of Donzacq, France.

Helicosphaera seminulum lophota Bramlette and Sullivan, **new subspecies**

Plate 4, figures 3a–b, 4

Description: Differs from the nominate subspecies in being wider, especially at one end, and in having more distinct striae on the large end of the distal plate. The central opening is smaller, and the bar is more nearly parallel to the longitudinal than the transverse axis. Length 10–15μ.

Remarks: This subspecies is somewhat more similar to *Helicosphaera carteri* than the nominate subspecies in the greater asymmetry of the plan view outline. Between crossed nicols it shows a peculiar and distinctive crenulation in the extinction line across the larger end, which appears to be related to the coarse striae of this part. This subspecies is the more common form in the upper strata and appears to have been derived from the nominate subspecies of the lower strata. The specimen shown in plate 4, figure 4, seems to represent the intermediate forms.

Holotype: U.S.N.M. 564213, Canoas OC–4.

Paratype: U.S.N.M. 564214, Lodo 67.

Distribution: Locally rare in the upper part of Unit 3 (Lower Eocene) and common in Units 4 and 5 (Middle Eocene). Occurs in the Weches Formation (Middle Eocene) of Sabine River, Texas, and in the Middle Eocene of Gibret and Donzacq, France.

Genus **Lophodolithus** Deflandre, 1954

"Coccolithe asymétrique, avec une différenciation par élargissement de l'un des pôles, dont la marge est généralement plus développée."

Additional study of the type species, *Lophodolithus mochlophorus*, from topotypic and California samples indicates that the characteristic asymmetry of the plan view has a corresponding asymmetry in side view, with the rim higher at the end with the wider flange. Polarized light reveals that the single transverse bar consists of at least two calcite segments with orientations differing from each other and from those of the elements in the adjacent part of the rim. This peculiar bar seems to be another significant feature of the genus, although it is not unique, as a similar one occurs in related forms lacking the asymmetry in shape, which are assigned to the new genus *Zygodiscus*.

Type species: Lophodolithus mochlophorus Deflandre, 1954.

Lophodolithus mochlophorus Deflandre
Plate 4, figure 6a–c

Lophodolithus mochlophorus DEFLANDRE, 1954, *in* DEFLANDRE AND FERT, Ann. Pal., vol. 40, p. 147, pl. 12, figs. 20–23; text-figs. 69–71.

Remarks: The Lodo specimens, as well as most topotype specimens, show the narrow end more rounded than the ogival or pointed shape indicated by Deflandre's holotype. However, the wide end of the rim is even more broadly rounded, and the species is distinctive in the degree of this asymmetry and in having developed fine crenulations within the wide flange. The side view (pl. 4, fig. 6b) also shows a conspicuous asymmetry, with the rim distinctly higher at the end with wide flange. Development from *Lophodolithus nascens* is indicated in the discussion of that species.

Hypotype: U.S.N.M. 564215, Canoas OC–4.

Distribution: Locally present in Units 4 and 5 (Middle Eocene). Recorded from the lower Lutetian (Middle Eocene) of Donzacq, France; present in the Weches Formation (Middle Eocene) of Sabine River, Texas.

Lophodolithus nascens Bramlette and Sullivan, new species
Plate 4, figures 7a–c, 8a–c

Description: Coccoliths with a thin rim higher at one end and turned out at the top to form a narrow flange, which is distincly wider at the high end of typical specimens. Central opening spanned by a basal transverse bar, with the component calcite in more than one orientation. Length 10–16μ.

Remarks: Specimens are more conspicuous between crossed nicols than in normal light, especially the thin flange and the bar. The early forms of this species, with less asymmetry in height of rim and width of flange (pl. 4, fig. 8a–c), are similar to *Zygodiscus adamas* (pl. 4, fig. 10a–c), and appear to have developed from it. Specimens with a conspicuously wider flange at one end are present throughout the local range of this species, although they are more common in the upper part, where they differ from *Lophodolithus mochlophorus* only in the lack of crenulations within the flange at the broader end and in the less ogival shape of the rim at the opposite end. A lineage involving these species seems clearly indicated.

Holotype: U.S.N.M. 564216, Lodo 33.

Paratype: U.S.N.M. 564217, Lodo 33.

Distribution: Locally present in Units 2, 3, and 4 (Paleocene to Middle Eocene). Present in the Lower Eocene of Pakistan, Denmark, and the Marnière de Sourbé, east of Doazit, France; rare in the lower Lutetian (Middle Eocene) of Donzacq, France.

Lophodolithus reniformis Bramlette and Sullivan, new species
Plate 4, figure 5a–c

Description: Specimens reniform, with the rim slightly higher at one end and arched upward at the inturned side. Rim turned out at top to form a narrow flange, which is wider at the high end of most specimens. Central opening spanned by a transverse bar. Length 10–15μ.

Remarks: Although this form is distinguished from *Lophodolithus nascens* by its reniform shape in plan view, it is nevertheless closely related to that species. It resembles the genus *Nephrolithus* Gorka (1957, p. 282) only in general outline.

Holotype: U.S.N.M. 564218, Lodo 67.

Distribution: Locally present in Units 3 and 4 (Lower and Middle Eocene).

Genus **Rhabdosphaera** Haeckel, 1894

This genus is well represented by living species, including the type species, *Rhabdosphaera claviger* Murray and Blackman (1898). The basal plate of the elongate rhabdolith has a central hole, continuous with a canal in the superimposed high stem.

The paragenus name *Rhabdolithus* for fossil rhabdoliths seems unnecessary here, as rhabdoliths with the above-mentioned features constitute the main basis for characterizing the living genus. Similar fossil forms may thus be assigned here with as much assurance as are many other kinds of fossils. Dimorphic forms on individual rhabdospheres are not known in *Rhabdosphaera*,

and assignment to a paragenus until the complete rhabdosphere is recognized also seems unnecessary on such a basis. Similar reasons were mentioned for using the name *Coccolithus* rather than the form genus name *Tremalithus*.

A circular basal plate is normal for rhabdoliths assigned to *Rhabdosphaera* but is perhaps of less fundamental significance than assumed by Kamptner (1958, p. 75), and, as Deflandre (1959, p. 137) has indicated, to distinguish it from slightly elliptical plates requires exact orientation of specimens, which is difficult to achieve with elongate rhabdoliths. Only two of the rhabdolith-like forms described here, however, have other than circular basal plates, and these two are otherwise peculiar and are only provisionally assigned to *Rhabdosphaera*.

Rhabdosphaera crebra (Deflandre)
Plate 5, figures 1–3

Rhabdolithus creber DEFLANDRE, 1954, *in* DEFLANDRE AND FERT, Ann. Pal., vol. 40, p. 157, pl. 12, figs. 31–33; text-figs. 81–82.

Remarks: This common Eocene form is identical with topotype specimens in the shape of the stem and the enlargement or collar at the junction with the basal plate. Variation is evident only in the height (length of stem).

Hypotypes: U.S.N.M. 564219–21, Lodo 52.

Distribution: Locally present in Units 3 and 4 (Lower and Middle Eocene). Recorded from the lower Lutetian (Middle Eocene) of Donzacq, France. Also present in the Lower Eocene of Gan, France, and in the Weches Formation (Middle Eocene) of Sabine River, Texas.

Rhabdosphaera inflata Bramlette and Sullivan, new species
Plate 5, figures 4a–b, 5

Description: Rhabdoliths much inflated in middle part of stem, having a small circular base with small central opening. Slightly rugose stem enlarges not far above the base to a diameter greater than the base, and then tapers gradually to a sharp tip. Height 16-20μ.

Remarks: This distinctive form shows variations in height corresponding to the length of the tapering tip.

Holotype: U.S.N.M. 564222, Canoas OC–3.

Paratype: U.S.N.M. 564223, Canoas OC–3.

Distribution: Locally common in Unit 5 (Middle Eocene). Common in the Middle Eocene of Gibret and Carrière de Nousse, in southwestern France.

Rhabdosphaera morionum (Deflandre)
Plate 5, figures 12a–b, 13

Calyptrolithus morionum DEFLANDRE, 1954, *in* DEFLANDRE AND FERT, Ann. Pal., vol. 40, p. 147, pl. 12, figs. 7–8; text-figs. 63–64.

Remarks: This peculiar and variable species is represented in the California material by some specimens similar to the holotype and by others with a range of variation comparable with that shown by topotype material. The low and inflated or bulbous stem is distinctive, but specimens with somewhat higher stems and less inflation near the base (pl. 5, fig. 13) are more like the usual rhabdolith. Between crossed nicols, the indicated arrangement of component crystallites, especially in the base, is also like that in *Rhabdosphaera*, and the species is therefore assigned to that genus.

Hypotypes: U.S.N.M. 564224, Lodo 58, and 564225, Domengine OC–2.

Distribution: Locally rare and sporadic throughout Units 3 and 4 (Lower and Middle Eocene). Recorded from the lower Lutetian (Middle Eocene) of Donzacq, France.

Rhabdosphaera perlonga (Deflandre)
Plate 5, figure 7a–c

Rhabdolithus perlongus DEFLANDRE, 1954, *in* DEFLANDRE AND FERT, Ann. Pal., vol. 40, p. 158, pl. 12, figs. 34–35; text-fig. 86.

Remarks: The forms assigned to this species include some that are identical with *Rhabdolithus perlongus* Deflandre, but also may include his *R. pinguis*, as the distinguishing features of the two species commonly seem obscure.

Hypotype: U.S.N.M. 564226, Lodo 71.

Distribution: Locally common throughout Unit 3 (Lower Eocene) and rare in Unit 4 (Middle Eocene). Recorded from the lower Lutetian (Middle Eocene) of Donzacq, France. Also present in the Lower Eocene of Gan, France, and in the Weches Formation (Middle Eocene) of Sabine River, Texas.

Rhabdosphaera? rudis Bramlette and Sullivan, new species
Plate 5, figure 6a–b

Description: Rhabdoliths urn-shaped, large, robust, and rugose. Base elliptical; stem in the form of a large round tube, rapidly flaring to the diameter of the base and then gradually tapering to a truncate tip. Stem buttressed by four ridges, which extend upward along the sides of the narrow lower part and appear as an X in proximal view, where they join the base. Central canal very large in middle part. Height 13–15μ.

Remarks: This robust and rugose form has a very distinctive character and is questionably assigned to the genus. Forms of somewhat intermediate character between this species and the peculiar Cretaceous form *Lucianorhabdus cayeuxi* Deflandre (1959, pp. 142–143) occur in the Paleocene of France, which suggests a possible phylogenetic series.

Holotype: U.S.N.M. 564227, Lodo 66.

Distribution: Locally rare and sporadic in Unit 3 (Lower Eocene).

Rhabdosphaera scabrosa (Deflandre)
Plate 5, figure 11a–b

Rhabdolithus scabrosus Deflandre, 1954, *in* Deflandre and Fert, Ann. Pal., vol. 40, p. 158, pl. 12, fig. 30; text-fig. 85.

Remarks: The uniform taper from base to tip and the slight rugosity of the stem are distinctive features of these specimens and of topotypes of the species.

Hypotype: U.S.N.M. 564228, Domengine OC–2.

Distribution: Locally present in the middle of Unit 3 and in Unit 4 (Lower and Middle Eocene). Recorded from the lower Lutetian (Middle Eocene) of Donzacq, France; common in the Weches Formation (Middle Eocene) of Sabine River, Texas.

Rhabdosphaera? semiformis Bramlette and Sullivan, new species
Plate 5, figures 8–9, 10a–b

Description: Rhabdolith-like in general form but lacking some of the normal features. Base on one side of the stem, and stem like a longitudinal half of a tapering tube. Height about 19μ.

Remarks: This very peculiar form is assigned very questionably to the genus *Rhabdosphaera*, as it is unlike all other species of the genus. It appears similar to a longitudinally split half of *Zygrhablithus bijugatus*. The many specimens, however, show no evidence of such breakage, and their restricted occurrence is not consistent with such an interpretation.

Holotype: U.S.N.M. 564229, Canoas OC–3.

Paratypes: U.S.N.M. 564230–31, Canoas OC–3.

Distribution: Locally common in Units 4 and 5 (Middle Eocene).

Rhabdosphaera tenuis Bramlette and Sullivan, new species
Plate 5, figure 14a–b

Description: Rhabdoliths with relatively small circular base and high, slender stem uniformly tapering to a sharp tip. Central canal small. Height about 25μ.

Remarks: This very elongate but otherwise rather nondescript form may prove difficult to distinguish from some rhabdoliths in the Upper Eocene but appears to be stratigraphically significant because it is the common form above the range of the other rhabdoliths recorded here, and the same range relations appear in the Eocene elsewhere. It is slightly rugose like *Rhabdosphaera scabrosa*, but the lower part of the stem is smaller in diameter and thus has distinctly less taper.

Holotype: U.S.N.M. 564232, Canoas GC–2.

Distribution: Locally present in Units 4, 5, and 6 (Middle Eocene). Common in the upper part of the Middle Eocene and in the Upper Eocene of many regions.

Rhabdosphaera truncata Bramlette and Sullivan, new species
Plate 5, figure 15a–b

Description: Rhabdoliths with circular base and an enlargement or collar above the basal plate. Stem nearly parallel-sided, though typically somewhat constricted in the middle part, and with truncate tip. Central canal large. Height 9–12μ.

Remarks: If specimens were rare and poorly preserved they might be interpreted as broken, but where they occur abundantly they consistently have the truncate stem.

Holotype: U.S.N.M. 564233, Lodo 37.

Distribution: Locally present in Unit 3 (Lower Eocene). Present in the Lower Eocene of the Marnière de Sourbé, east of Doazit, France.

Rhabdosphaera vitrea (Deflandre)
Plate 5, figures 16–17

Rhabdolithus vitreus Deflandre, 1954, *in* Deflandre and Fert, Ann. Pal., vol. 40, pp. 157–158, pl. 12, figs. 28–29; text-figs. 83–84.

Remarks: Like topotypes of this species, these rhabdoliths are small and have so delicate a stem that a canal, if present, is obscure. The basal plate is thin and rather flat but with a thickened collar at the junction with the stem. Figure 16 on plate 5 shows a specimen replaced by fluorite, and therefore the stem appears more distinct in Canada balsam.

Hypotypes: U.S.N.M. 564234, Lodo 52, and 564235, Lodo 67.

Distribution: Locally sporadic and rare in Units 3 and 4 (Lower and Middle Eocene). Recorded from the lower Lutetian (Middle Eocene) of Donzacq, France. Also present in the Cane River Formation (Middle Eocene) of Louisiana.

Rhabdosphaera sp.
Plate 5, figure 18a–b

Remarks: This small, nondescript rhabdolith, which occurs only in the Paleocene, is different from the other recorded forms but lacks distinctive features for specific identification.

Hypotype: U.S.N.M. 564236, Lodo 32.

Distribution: Locally present throughout Unit 2 (Paleocene).

Genus **Zygodiscus** Bramlette and Sullivan, **new genus**

Coccoliths with an elliptical rim, a transverse bar with more than one segment of different calcite orientation, and some vestige, at least, of a basal plate.

The genus thus has some features of three other genera: *Zygolithus*, *Discolithus*, and *Lophodolithus*, and is characterized by the combination of these features. The elliptical rim spanned by the transverse bar is like *Zygolithus*, but similarity to *Discolithus* is indicated by some extension of a plate into the basal area. The peculiar internal structure of the bar is unlike that of *Zygolithus* but identical with that of *Lophodolithus*, although *Lophodolithus* is distinctive in its asymmetry. In the discussion of *L. nascens*, progressive increase of the asymmetry in that species and possible development from *Zygodiscus* were indicated.

Between crossed nicols in distal view, the extinction lines across the rim and plate show a dextral curvature, as in *Lophodolithus* and *Zygolithus*, unlike the sinistral curvature usual in *Discolithus*. Although the bar appears uniform in normal light, the Quartz Red 1 plate with crossed nicols indicates at least two segments of the bar having different crystallite orientation, and both orientations are more nearly perpendicular than parallel to the length of the bar. Precise interpretation of the arrangement of component crystallites in the bar seems possible only from electron microscope examination of a carbon replica of the coccolith.

Type species: Zygodiscus adamas Bramlette and Sullivan, n. sp.

Zygodiscus adamas Bramlette and Sullivan, **new species**
Plate 4, figures 9a–c, 10a–c

Description: Coccolith with a thin rim of uniform height, turned out at the top to form a very narrow flange. Basal plate with inconspicuous to large openings on each side of the diamond- or lozenge-shaped transverse bar. Length 11–13μ.

Remarks: In polarized light the transverse bar shows the peculiar difference in crystallite orientation within segments characteristic of this genus and of *Lophodolithus*, as shown in plate 4, figure 10a–b. The openings in the basal plate are inconspicuous in early forms of the species but are increasingly larger in later forms, which thus have little of the basal plate. The lozenge-shaped form of the bar (fig. 9a) is also modified in the specimens with large openings (fig. 10a). These later forms thus resemble those early forms of *Lophodolithus nascens* which show little of the asymmetry in height of rim and width of flange that is characteristic of that species. The development of *Lophodolithus* from *Zygodiscus* thus seems well supported by forms of these two species having characters transitional between the two genera.

Holotype: U.S.N.M. 564237, Lodo 32.

Paratype: U.S.N.M. 564238, Lodo 32.

Distribution: Locally present throughout Unit 2 (Paleocene) and in the basal part of Unit 3 (Lower Eocene).

Zygodiscus plectopons Bramlette and Sullivan, **new species**
Plate 4, figure 12a–d

Description: Coccoliths with a thick rim thinning toward the central opening, which is restricted to less than half the total width and is spanned by a thick transverse bar having the complex crystal orientations characteristic of the genus. Length 7–9μ.

Remarks: The concave slope of the rim on the distal side of specimens results in a thinning inward that is gradual, unlike the usual abrupt change from rim to basal plate of discoliths, although this is not very obvious in plan view. The bridging bar appears uniform in normal light but in polarized light it is seen to consist of two twisted longitudinal segments of different crystal orientation, although both orientations are more nearly perpendicular than parallel to the length of the bar. The bar is thus quite distinct from that of *Zygolithus*, which it resembles otherwise more than do the other species of *Zygodiscus*.

Holotype: U.S.N.M. 564239, Lodo 31.

Distribution: Locally common throughout Unit 2 (Paleocene) and very rare (reworked? specimens) in Unit 3 (Lower Eocene). Occurs in the Bashi Formation (Paleocene or Lower Eocene) of Alabama, and in the type Thanetian of England.

Zygodiscus aff. **Z. plectopons** Bramlette and Sullivan
Plate 4, figure 13a–e

Remarks: Perhaps subspecific distinction may prove desirable for this form, which is not only larger than normal for the species (9–13μ), but also shows somewhat more differentiation into rim and basal plate, although this is not apparent in plan view. It has a broader rim than is typical for the species, the central

opening is restricted to one-third or less of the total width, and some specimens have the central area completely closed. Between crossed nicols, the extinction lines curve strongly as compared with the species, but this probably reflects their greater length because of the wider rim.

Hypotype: U.S.N.M. 564240, Lodo 6+1.

Distribution: Locally common in Unit 1 (Paleocene) and very rare (reworked?) in Unit 3 (Lower Eocene).

Zygodiscus sigmoides Bramlette and Sullivan, new species
Plate 4, figure 11a–e

Description: Coccoliths with a low rim and little of the basal plate except that which extends in from the rim along the sides of the transverse bar. This bar normally shows a sigmoid curvature, accentuated by the different orientation of the two calcite segments, which is apparent in polarized light. The bar is arched and commonly supports a central knob or very short stem. Length of base 9–11μ.

Remarks: Some extension from the rim of a partial basal plate, obscure in Canada balsam, is seen distinctly between crossed nicols (pl. 4, fig. 11d). It is unusual in that the orientation of component crystallites in the plate is quite different from that in the rim, as is evident with the addition of the Quartz Red 1 plate. This is an unusual feature for *Zygodiscus*, but otherwise the characters are similar to those of other species of the genus.

Holotype: U.S.N.M. 564241, Lodo 31.

Distribution: Locally common throughout Units 1 and 2 (Paleocene); a few very rare specimens (reworked?) in the upper part of Unit 3 (Lower Eocene). Occurs in the Nanafalia Formation (Paleocene) of Alabama, and in the type Thanetian of England. Common in the Paleocene 2.95 km. south of Gan, France, and in the upper part of the type Danian of Denmark.

Genus **Zygolithus** Kamptner, 1955 (1949?)

An inadequately defined generic name generally used for coccoliths consisting of an elliptical rim transversely spanned by one bar or two cross bars.

Species here assigned provisionally to this genus may require a new generic name following restudy after the designation of a genotype; none has yet been designated. The several species which were classed as *Zygolithus* by Kamptner (1956, p. 9) in the late Tertiary of Rotti appear different from ours in having cross bars attached at the top of the rim and apparently continuous in calcite orientation with the rim. These species were evidently represented by very rare forms, however, as similar specimens could not be found in our examination of a part of the type material.

Species here classified as *Zygolithus* show a dextral curvature of the extinction lines across the rim in distal view between crossed nicols, and different crystal orientation in the bar and adjacent rim, but the consistency and significance of these features remain doubtful, and are not considered definite generic characters.

Zygolithus chiastus Bramlette and Sullivan, new species
Plate 6, figures 1a–d, 2a–b, 3a–b

Description: Zygoliths with a thin rim and open central area transversely spanned by two straight bars crossing to form a narrow x-shaped structure or by one straight and one slightly to distinctly sigmoid bar crossing more nearly at right angles. Bars slightly enlarged at juncture with rim. Length 7–11μ.

Remarks: Several taxa were tentatively distinguished and recorded, based on the differences in the cross bars. However, the existence of intermediate forms and the doubtful significance of the dominance of any one form in a restricted part of the sequence caused the abandonment of this subdivision as apparently unjustified.

Holotype: U.S.N.M. 564242, Lodo 6+1.

Paratypes: U.S.N.M. 564243, Lodo 22, and 564244, Lodo 36.

Distribution: Locally common throughout Units 1 and 2 (Paleocene) and present throughout most of Unit 3 (Lower Eocene). Occurs in the Nanafalia Formation (Paleocene) of Alabama, in the type Thanetian of England, in the type Danian of Denmark, and is common in the Paleocene 2.95 km. south of Gan, France.

Zygolithus crux (Deflandre and Fert)
Plate 6, figures 8–10

Discolithus crux Deflandre and Fert, 1952, C. R. Acad. Sci., vol. 234, p. 2101, text-fig. 8; 1954, Ann. Pal., vol. 40, p. 143, pl. 14, fig. 4; text-fig. 55.

Remarks: The Lodo specimens of this small and delicate form differ from the species described by Deflandre and Fert (1952) in having the cross usually oriented very slightly off the axes of the ellipse, with a slight thickening at the center of the cross, and in being somewhat larger, ranging in length up to 9μ. However, they seem to be within the range of variation shown by topotype specimens of this species. The transverse bars are not like a rudimentary basal plate, and it thus seems best assigned to *Zygolithus*.

Hypotypes: U.S.N.M. 564245, Lodo 46, and 564246–47, Lodo 67.

Distribution: Locally rare in Units 3, 4, and 5 (Lower to Middle Eocene). Recorded from the lower Lutetian (Middle Eocene) of Donzacq, France.

Zygolithus distentus Bramlette and Sullivan, **new species**
Plate 6, figures 4a–c, 5, 6a–d, 7

Description: Specimens with a thick rim extending over most of the central area and a central opening, largely filled by a somewhat obscure transverse x-shaped structure varying in robustness. Distinct lines at each end extend from the inner margin across most of the rim. Length 5–9μ.

Remarks: This unique small form is characterized by its broad rim, marked by longitudinal lines, and by its unusual x-shaped structure, the bars of which vary from distinct ones, enlarged where they join the rim and only partially occupying the central opening, to very robust bars that form a four-leaf-clover-shaped structure (pl. 6, figs. 4–5), which completely fills the small central opening. It differs from the other species here assigned to *Zygolithus* in having very little central opening and in having longitudinal lines similar to several species of *Discolithus*. There is, however, no obvious differentiation of a distinct basal plate and a marginal rim as in *Discolithus*. The x-shaped structure of this species and the dextral curvature of the extinction lines in distal view between crossed nicols are usual in other species here classed as *Zygolithus* and give some additional basis for provisional assignment to this genus.

Holotype: U.S.N.M. 564248, Lodo 22.

Paratypes: U.S.N.M. 564249–50, Lodo 22, and 564251, Lodo 32.

Distribution: Locally common throughout Unit 2 (Paleocene); very rare (reworked?) specimens in Unit 3 (Lower Eocene). Occurs in the Bashi Formation (Paleocene or Lower Eocene) and the Nanafalia Formation (Paleocene) of Alabama, in the type Thanetian of England, and is common in the Paleocene 2.95 km. south of Gan, France.

Zygolithus dubius Deflandre
Plate 6, figures 12–13, 14a–b

Zygolithus dubius DEFLANDRE, 1954, *in* DEFLANDRE AND FERT, Ann. Pal., vol. 40, p. 149, text-figs. 43–44, 68.– MARTINI, 1958 (part), Senckenbergiana leth., vol. 39, no. 5–6, pp. 369–370, pl. 1, figs. 1a, 1c (not fig. 1b).

Remarks: These common zygoliths are identical with topotypes of the species. The open central area is transversely spanned by an H-shaped rather than x-shaped structure, which extends higher than the rim. The side view shown in Deflandre's text-figure 68 evidently represents another form, as he indicated was probable. The bars of the central structure and the rim are higher than thick (pl. 6, fig. 14), and this feature, along with the nearly vertical orientation of the component crystallites, results in strong relief of the plan view in Canada balsam. The crystallite structure differs from that of the other species here assigned to *Zygolithus*, except the closely related *Z. protenus*, in that the extinction lines seen between crossed nicols on the rim are very vague. Both species, however, are similar to *Chiphragmalithus* in this respect and in having high septum-like bars. In addition, forms with weakly developed barbs around the periphery but otherwise like *Z. dubius* are known elsewhere. It thus appears that *Z. dubius* and *Z. protenus* are intermediate forms that gave rise to the distinctive species assigned to *Chiphragmalithus*.

Hypotypes: U.S.N.M. 564252, Lodo 58; 564253, Domengine OC–2; and 564254, Canoas OC–4.

Distribution: Locally present throughout Units 3–6 (Lower and Middle Eocene). Common in the Eocene of many regions; originally recorded from the lower Lutetian (Middle Eocene) of Donzacq, France.

Zygolithus junctus Bramlette and Sullivan, **new species**
Plate 6, figure 11a–b

Description: Zygoliths with a thin rim and open central area transversely spanned by a very delicate x-shaped structure, the bars of which cross at a very small angle and are distinctly enlarged where they join the rim. Length 11–15μ.

Remarks: This form is distinguished from *Zygolithus chiastus* by its distinctly larger size and more delicate x-shaped structure, the bars of which cross at such a small angle that they appear joined except toward the periphery.

Holotype: U.S.N.M. 564255, Lodo 6+1.

Distribution: Locally present in Unit 1 (Paleocene). Occurs in the Nanafalia Formation (Paleocene) of Alabama.

Zygolithus protenus Bramlette and Sullivan, **new species**
Plate 6, figure 15a–b

Description: Zygoliths elliptical, with a thin, steeply sloping rim. Open central area transversely spanned by an x-shaped structure consisting of two bars equal in height to the rim. Bars and rim are higher than thick. Length 7–9μ.

Remarks: This form, occurring lower in the Lodo section and appearing to give rise to *Zygolithus dubius*, differs from that species in having the central area transversely spanned by an x-shaped rather than H-shaped structure and in having a less elongate elliptical form. It differs from *Z. chiastus* in having a more nearly vertical rim, which thus appears narrower in plan view, and bars that do not enlarge where they join the rim, and in showing extinction lines only vaguely between crossed nicols. *Zygolithus dubius* Deflandre of Martini (1958 (part), p. 356, pl. 1, fig. 1b (not figs. 1a, 1c)) may be the same form.

Holotype: U.S.N.M. 564256, Lodo 32.

Distribution: Locally rare in Unit 2 (Paleocene). Occurs at the Tuilerie (Lower Eocene) of Gan, France.

Genus Zygrhablithus Deflandre, 1959

"Rhabdolithe combiné à un zygolithe, composé d'une embase elliptique ou subcirculaire, barrée par uncroisillon en x surmonté d'une hampe généralement complexe, celle-ci pouvant être le prolongement direct du croisillon."

Type species: Zygrhablithus bijugatus (Deflandre).

Zygrhablithus bijugatus (Deflandre)
Plate 6, figures 16a–b, 17a–c, 18

Rhabdolithus costatus DEFLANDRE, 1954, *in* DEFLANDRE AND FERT, Ann. Pal., vol. 40, p. 157, pl. 11, figs. 8–11; text-figs. 41–42, 77–79.

Zygolithus bijugatus DEFLANDRE, 1954 (part), *in* DEFLANDRE AND FERT, Ann. Pal., vol. 40, p. 148, pl. 11, fig. 21 (not text-fig. 59).

Zygrhablithus bijugatus (Deflandre). – DEFLANDRE, 1959, Rev. Micropal., vol. 2, pp. 135–136.

Remarks: This common though peculiar form resembles a rhabdolith in side view and a zygolith in end view. Deflandre therefore applied this new generic name and gave much discussion of the type species. The size, especially the height, are very variable. The appearance is quite different in the various orientations illustrated, but recognition of the species is not difficult if this fact is taken into account. A general trend toward larger and heavier specimens upward from the Lower Eocene to the Oligocene is evident here and elsewhere. Very small specimens which may belong to this species occur in Unit 2 of the Paleocene but were not recorded.

Hypotypes: U.S.N.M. 564257, Domengine OC–1, and 564258–59, Domengine OC–2.

Distribution: Locally common in Units 3, 4, and 5 (Lower and Middle Eocene). Common in the Eocene of many regions; originally recorded from the Upper Eocene of Oamaru, New Zealand.

Zygrhablithus simplex Bramlette and Sullivan, new species
Plate 6, figures 19, 20a–b, 21–22

Description: Specimens with elliptical rim slightly arched upward and bridged by an arching transverse bar which supports a long stem showing faint spiral lines and tapering near the tip to a blunt point. Central canal obscure in some specimens. Length of base 8–11μ. Height 13–18μ.

Remarks: This distinctive form is provisionally assigned to this genus although it has only one transverse bar. The stem with canal is like that of *Rhabdosphaera*, but the base resembles that of *Zygodiscus*. Extinction between crossed nicols for the stem is parallel to the polarization planes, with the crystallites arranged at right angles to the length of the stem, as indicated with the quartz wedge. Broken specimens occur rather commonly, in which the rim is broken away leaving the stem with forked remnants of the bar (pl. 6, fig. 20). The vague spiral arrangement in the stem is more apparent between crossed nicols (fig. 20b).

Holotype: U.S.N.M. 564260, Lodo 32.

Paratypes: U.S.N.M. 564261–62, Lodo 6+1, and 564263, Lodo 32.

Distribution: Locally present in Units 1 and 2 (Paleocene); very rare specimens (reworked?) in Unit 3 (Lower Eocene). Occurs in the Paleocene 2.95 km. south of Gan, France, and in the type Danian of Denmark.

Genus Coccolithites Kamptner, 1955

This generic designation is applied here, as by Kamptner, provisionally to some fossil coccoliths with characters that are either obscure or not sufficiently studied to warrant assignment to known genera or the establishment of new generic names. Some of the species here included in the one genus, however, are obviously not closely related and need further study.

Coccolithites cribellum Bramlette and Sullivan, new species
Plate 7, figures 5a–b, 6a–b

Description: Coccoliths elliptical, consisting of two closely appressed plates. Distal plate with wide outer slope, straight, radiating fine striae, and very narrow inner slope. Central area perforated by several rows of fine pores, with a vague cross indicating division of a central plate into quadrants. Length 6–14μ, usually about 11μ.

Remarks: The structure of this peculiar and scarce form is difficult to determine, but it appears similar to a Cretaceous species which is discussed under the form provisionally recorded here as *Coccolithites* sp.

Holotype: U.S.N.M. 564268, Lodo 46.

Paratype: U.S.N.M. 564269, Lodo 63.

Distribution: Locally rare throughout most of Unit 3 (Lower Eocene).

Coccolithites delus Bramlette and Sullivan, new species
Plate 7, figures 1a–c, 2a–b

Description: Coccoliths with subelliptical rim, which appears nearly rectangular in plan view due largely to the strong curvature evident in side view. A conspicuous groove in the rim produces a ridge along the inner margin of the proximal side, resulting in an

appearance like two closely appressed plates. Bars span the central opening in the major and minor axes. Length 7–11μ.

Remarks: Between crossed nicols with the Quartz Red 1 plate, it is evident that the component crystallites of the rim are oriented more nearly parallel to the rim than radial, and that those of the cross bars are oriented at about 45° to the bar length. A consistently much smaller but otherwise apparently identical form is included here with the typical form. Only this much smaller form is known in the Paleocene here and elsewhere, however, and subspecific distinction may prove desirable.

Holotype: U.S.N.M. 564264, Lodo 80.

Paratype: U.S.N.M. 564265, Lodo 80.

Distribution: Locally common throughout Units 2–5 (Paleocene to Middle Eocene). Common in the Lower and Middle Eocene of many regions, including the Weches Formation (Middle Eocene) of Sabine River, Texas, the lower Lutetian (Middle Eocene) of Donzacq, France, and the Lower Eocene of Pakistan.

Coccolithites aff. C. delus Bramlette and Sullivan
Plate 7, figures 3–4

Remarks: This form appears to be identical with the typical species except for the lack of cross bars and the somewhat less conspicuous ridge in the rim. It is usually associated with the typical species but much less common. A very similar or identical form is common, however, to the exclusion of typical *Coccolithites delus* in an Eocene sample from the Mid-Pacific Mountains and was described and named by E. Kamptner in an unpublished manuscript. Additional study may justify subspecific distinction from *C. delus* s. s.

Hypotypes: U.S.N.M. 564266, Lodo 80, and 564267, Domengine OC–2.

Distribution: Locally present throughout Units 3–6 (Lower and Middle Eocene). Occurs in the Lower and Middle Eocene of many regions, including the lower Lutetian of Donzacq, France.

Coccolithites distichus Bramlette and Sullivan, new species
Plate 7, figure 8a–c

Description: Coccoliths elliptical, consisting of a very thin, flat plate with central openings bordered by a slight ridge. Central area with a grid consisting of 3–6, commonly 5, transverse bars which may vary in number on either side of the heavier, slightly raised longitudinal bar. Length 11–14μ.

Remarks: Except for the thick central grid, this distinctive form is difficult to see with transmitted light in Canada balsam, although the entire form is plainly visible between crossed nicols.

Holotype: U.S.N.M. 564270, Lodo 22.

Distribution: Locally present in Units 1 and 2 (Paleocene); very rare and sporadic (reworked?) specimens in Unit 3 (Lower Eocene). Common in the Paleocene 2.95 km. south of Gan and elsewhere in France, but consistently smaller than in California.

Coccolithites gammation Bramlette and Sullivan, new species
Plate 7, figures 7a–c, 14a–b

Description: Coccoliths circular and probably consisting of two very closely appressed plates of almost equal size, rather than a single plate. A somewhat depressed central area occupies less than half the total diameter, and a tiny central spot may represent a central opening. This form is especially distinctive between crossed nicols, as discussed below. Diameter 5–9μ.

Remarks: Between crossed nicols the outer part of the specimens is indistinct but the inner portion clearly shows the extinction cross, curving strongly in the form of a swastika. A large group of coccoliths with the original tight articulation is represented by the form illustrated in plate 7, figure 14a–b. The slight curvature in this group indicates an unusually large size for the complete coccosphere, apparently much more than 100μ, although some compression without breakage and disaggregation is possible. The marked change in size of the coccoliths is probably toward a buccal opening.

Holotype: U.S.N.M. 564271, Lodo 46.

Hypotype: From the Tuilerie de Donzacq, Landes, France.

Distribution: Locally present in Units 3 and 4 (Lower to Middle Eocene). Occurs in the Weches Formation (Middle Eocene) of Sabine River, Texas, and in the lower Lutetian (Middle Eocene) of Donzacq, France.

Coccolithites macellus Bramlette and Sullivan, new species
Plate 7, figures 11–12, 13a–d

Description: Coccoliths elliptical, consisting of a very thin, nearly flat plate with somewhat depressed central area bordered by a slightly raised ridge. Central area longitudinally bisected by a line commonly interrupted toward each end by a small round opening. Length 9–15μ.

Remarks: This delicate form is difficult to see in Canada balsam except with crossed nicols. Specimens in the two lowermost Lodo samples have a smaller central area with a less well developed bordering ridge than is typical (pl. 7, figs. 11–12). However, occasional specimens of this character were found along with the more typical forms, and they are not considered distinct enough to warrant taxonomic separation.

Holotype: U.S.N.M. 564273, Lodo 33.

Paratypes: U.S.N.M. 564274–75, Lodo 6+1.

Distribution: Locally present in Units 1, 2, and 3 (Paleocene and Lower Eocene), rare except in the lower part of its range. Occurs in the Paleocene of Trinidad and 2.95 km. south of Gan, France.

Coccolithites sp.
Plate 7, figures 9a–b, 10

Remarks: This form is similar to or identical with a common Cretaceous species, and its rare occurrence in the Lodo section may be due to reworking from the older strata. The Lodo specimens are elliptical, consisting of a single plate slightly grooved around the periphery or of two very closely appressed plates. The central area within a narrow rim is somewhat irregularly perforated and divided into quadrants with different optical orientations and with the dividing line appearing as a vague cross.

Determination of whether it is formed of one or of two closely appressed plates and interpretation of the anomalous appearance between crossed nicols of the four central segments can best be made in a study of the abundant larger specimens in the Upper Cretaceous. It may be the same as the poorly illustrated form described as *Arkhangelskiella specillata* by Vekschina (1959, p. 67). It differs from *Coccolithites cribellum* in the coarser, more irregular perforations of the central area and the distinctly narrower peripheral part.

Hypotypes: U.S.N.M. 564276, Lodo 58, and 564277, Lodo 80.

Distribution: Locally rare and sporadic in Units 3 and 5 (Lower and Middle Eocene).

Family BRAARUDOSPHAERIDAE Deflandre

Genus Braarudosphaera Deflandre, 1947

"Coque dodécaédrique; 12 pentalithes pentagonaux, formés de plaquettes trapézoïdales très difficilement dissociables" (Deflandre, 1952*b*, p. 112).

The extensive discussion of the genus by Deflandre (1947) and of the common species *Braarudosphaera bigelowi* by Gaarder (1954) is not reviewed here. It is one of the few genera, other than those of the coccolithophorids proper, occasionally retaining the skeletal elements intact, with the 12 pentaliths in a dodecahedral form (pl. 8, fig. 4). However, the usually isolated pentaliths are quite distinctive. Although the genus is most common in the Eocene, forms referable to the modern *B. bigelowi* have persisted for an unusually long time since the late Cretaceous.

Braarudosphaera bigelowi (Gran and Braarud)
Plate 8, figures 1a–b, 2–5

Pontosphaera bigelowi GRAN AND BRAARUD, 1935, Jour. Biol. Board Canada, vol. 1, p. 389, text-fig. 67.

Braarudosphaera bigelowi (Gran and Braarud). – DEFLANDRE, 1947, C. R. Acad. Sci., vol. 225, p. 439, text-figs. 1–5. – DEFLANDRE, 1954, *in* DEFLANDRE AND FERT, Ann. Pal., vol. 40, pp. 165–166, pl. 10, figs. 8–13; pl. 13, figs. 7–9. – BRAMLETTE AND RIEDEL, 1954, Jour. Pal., vol. 28, no. 4, pp. 393–394, pl. 38, fig. 6a–b. – GAARDER, 1954, Rept. Sci. Results "Michael Sars" North Atlantic Deep-Sea Exped. 1910, vol. 2, no. 4, pp. 5–6, text-fig. 2. – MARTINI, 1958, Senckenbergiana leth., vol. 39, no. 5–6, p. 355, pl. 2, fig. 6a–b.

Remarks: The pentaliths of this species are variable in thickness and range greatly in diameter, from 8 to 27μ. Their periphery also varies, both in plan and side view, from being sharply angled to more commonly rounded. The original description of this species, from a sample of living plankton, failed to indicate the division of the pentaliths into five segments, but Gaarders' (1954) later studies show such a division of the pentaliths in the modern form. An extraordinary life span is indicated for the species, in that it occurs as early as the late Cretaceous.

Hypotypes: U.S.N.M. 564278, Lodo 19; 564279, Lodo 31; 564280–81, Lodo 32; and 564282, Lodo 67.

Distribution: Locally abundant throughout Unit 2 (Paleocene) and sporadic in Units 3 and 4 (Lower and Middle Eocene). Widely distributed in Cretaceous to Recent sediments of many regions.

Braarudosphaera discula Bramlette and Riedel
Plate 8, figures 6a–b, 7

Braarudosphaera discula BRAMLETTE AND RIEDEL, 1954, Jour. Pal., vol. 28, no. 4, p. 394, pl. 38, fig. 7.

Remarks: These discoid pentaliths might be classed as *Micrantholithus*, but the segments commonly show (pl. 8, fig. 7) a suggestion of the basic trapezoidal form of the genus *Braarudosphaera*. Forms with outlines more similar to *B. bigelowi* are common in the Danian of Europe. This species differs from *Pemma rotundum* Klumpp (1953, p. 381) in not having a central opening in the segments. Reexamination of topotype specimens shows that they are nearly biconvex, with an average thickness approximately one-half the diameter. The few Lodo specimens examined in side view are planoconvex, but this difference does not seem to justify another taxonomic unit, as such differences are common in *B. bigelowi* and in many species of *Micrantholithus*. Diameter ranges widely, from 6 to 21μ.

Hypotypes: U.S.N.M. 564283, Lodo 21, and 564284, Lodo 46.

Distribution: Locally rare in Units 2, 3, and 4 (Paleocene to Middle Eocene). Common in the Eocene of Cuba, southwestern France, and elsewhere.

Genus **Micrantholithus** Deflandre, 1950

"Pentalithes étoilés, à pièces triangulaires peu cohérentes, souvent isolées" (Deflandre, 1952*b*, p. 112).

In the various species, deviations from the basically triangular shape of the five segments are produced by modification of their marginal sides. Only pentaliths with segments of trapezoidal form are here excluded from *Micrantholithus* and are considered characteristic of the closely related genus *Braarudosphaera*. Many species of *Micrantholithus* are thick, like *Braarudosphaera*, and thus are likewise usually preserved as complete pentaliths.

Type species: Micrantholithus flos Deflandre.

Micrantholithus attenuatus Bramlette and Sullivan, **new species**
Plate 8, figures 8a–b, 9–11

Description: Pentaliths star-shaped, large for the genus, consisting of five V-shaped segments, the adjacent sides of which form long tapering rays. The segments vary from having adjacent sides equal to having one side three times as long as the other (pl. 8, figs. 9–11), this feature being consistent, however, within any one pentalith. Deeply indented margin of segments sharply angular to somewhat rounded. Overall diameter 14–27μ, usually about 20μ.

Remarks: This species is commonly represented by isolated segments of the pentaliths. Its probable development is discussed under *Micrantholithus* aff. *attenuatus*. This species is probably the same as a species of *Micrantholithus* described in a paper (in press) of E. Martini, and his specific name therefore may have priority.

Holotype: U.S.N.M. 564285, Lodo 67.

Paratypes: U.S.N.M. 564286–88, Lodo 67.

Distribution: Locally present in Unit 3 (Lower Eocene). Occurs in the Bashi Formation (Paleocene or Lower Eocene) and in the Nanafalia Formation (Paleocene) of Alabama, in the London Clay (Lower Eocene) of England, and in the Lower Eocene of the Tuilerie of Gan, France.

Micrantholithus aff. **M. attenuatus**
Bramlette and Sullivan
Plate 8, figure 12a–b

Remarks: The pentaliths of this form differ from typical *Micrantholithus attenuatus* in being smaller, ranging in overall diameter from 9 to 14μ, and in having segments with adjacent sides consistently equal in length. High in its recorded range it is associated with and may have given rise to forms typical of the species. In this same interval, some specimens also show a small web between the rays suggesting development into *M. flos*, which makes its first appearance here. It differs from *M. pinguis* in having pentaliths which are not as thick but with much longer and narrower rays.

Hypotype: U.S.N.M. 564289, Lodo 21.

Distribution: Locally present throughout Unit 2 and in the lower part of Unit 3 (Paleocene and Lower Eocene).

Micrantholithus basquensis Martini
Plate 8, figures 14a–c, 15

Micrantholithus basquensis MARTINI, 1959, Senckenbergiana leth., vol. 40, no. 5–6, p. 417, pl. 1, figs. 9–12.

Remarks: Examination of numerous specimens from any one locality shows that this species is subject to considerable variation. The California specimens are not identical with either of the photographed specimens shown by Martini but appear to be within the range of variation noted for this species in other samples. Marked differences in thickness produce some of the variations in general appearance. The distinctly depressed central part of the segments and the indentation in the middle of their outer margins cause the outline of the thicker parts of the pentalith to resemble the general outline of *Discoaster deflandrei*. Overall diameter 7–12μ.

Hypotypes: U.S.N.M. 564290–91, Domengine OC–2.

Distribution: Locally present in Unit 4 (Middle Eocene). Occurs in the Weches Formation (Middle Eocene) and in the Cook Mountain Formation (Middle Eocene) of Sabine River, Texas, in the type Lutetian region at Grignon, France, and was recorded from near Biarritz, France.

Micrantholithus bramlettei Deflandre
Plate 9, figure 2a–b

Micrantholithus bramlettei DEFLANDRE, 1954, *in* DEFLANDRE AND FERT, Ann. Pal., vol. 40, p. 167, pl. 13, fig. 22; text-fig. 117.

Remarks: Further study of the type material from the Lodo shows that the pentaliths of this species vary, some forms having segments with symmetrical trilobate outer margins, as figured by Deflandre (1954, text-fig. 117), but most having segments with asymmetrical bilobate outer margins, as illustrated by our figure 2 on plate 9. Various intermediate forms indicate that they represent a single species. Although the middle part of the segment margin is extended rather than indented as in most species of the genus, a thickening adjacent to the sutures, as in the type species, *Micrantholithus flos*, supports the generic assignment.

Hypotype: U.S.N.M. 564292, Lodo 31.

Distribution: Locally present throughout Unit 2 (Paleocene) and rare in the lower part of Unit 3 (Lower Eocene).

Micrantholithus concinnus Bramlette and Sullivan, **new species**
Plate 9, figure 1a–c

Description: Pentaliths consisting of five segments with asymmetrically bilobate outer margins. Major lobe of each segment broad, with sides paralleling the sutures and with rounded tip. Overall diameter 10–13μ.

Remarks: The pentaliths of this species are distinct from the bilobate variant of *Micrantholithus bramlettei* in that the outer margins of the segments show that the major lobe is wide and much less extended. No gradation between the two forms was observed, although they appear to be closely related. As in *M. bramlettei*, the thickening adjacent to the sutures supports the generic assignment.

Holotype: U.S.N.M. 564293, Lodo 32.

Distribution: Locally rare in Unit 2 (Paleocene).

Micrantholithus crenulatus Bramlette and Sullivan, **new species**
Plate 9, figures 3a–b, 4

Description: Pentaliths with thickness equal to about half the diameter. Segments triangular or with slightly concave outer margin, which is somewhat crenulate and commonly shows a depression or thinning at the middle. Overall diameter 7–12μ.

Remarks: This species differs from *Micrantholithus basquensis* in having pentaliths more clearly pentagonal in shape, with segments lacking a central depression. However, the general outline and the median depression of the outer margin of the segments (pl. 9, fig. 4) suggest that the two species may be closely related.

Holotype: U.S.N.M. 564294, Domengine OC–2.

Paratype: U.S.N.M. 564295, Domengine OC–2.

Distribution: Locally rare in Units 2 and 3 (Paleocene and Lower Eocene) and more common in Unit 4 (Middle Eocene).

Micrantholithus entaster Bramlette and Sullivan, **new species**
Plate 9, figures 5a–c, 6, 7a–b

Description: Pentaliths star-shaped, consisting of five V-shaped segments, the adjacent sides of which form tapering rays with blunt to acutely pointed tips. Indentation between rays only slightly rounded. Central area thickened on one side to form a superimposed star, smaller but as much as twice as thick, with the tips alternating with the marginal ones of the pentalith. Overall diameter 9–20μ.

Remarks: The pentaliths of this species are distinct in having a thick and conspicuous superimposed central star, although this development appears less conspicuously in some other members of the genus. Rare forms of somewhat smaller size, with a delicate web between the rays and showing the conspicuous central star (pl. 9, fig. 6), may be a variant of the species. The tendency to develop an intermediate web is noted in *Micrantholithus attenuatus* and others.

Holotype: U.S.N.M. 564296, Lodo 32.

Paratypes: U.S.N.M. 564297–98, Lodo 31.

Distribution: Locally present throughout Unit 2 (Paleocene).

Micrantholithus flos Deflandre
Plate 9, figure 8a–b

Micrantholithus flos DEFLANDRE, 1950, C. R. Acad. Sci., vol. 231, p. 1157, text-figs. 8–11. – DEFLANDRE, 1954, *in* DEFLANDRE AND FERT, Ann. Pal., vol. 40, p. 166, pl. 13, figs. 10–11; text-figs. 113–114. – MARTINI, 1958, Senckenbergiana leth., vol. 39, no. 5–6, p. 356, pl. 1, fig. 2a–c.

Remarks: The pentaliths recorded here are generally typical of the species. However, some variants are included which have the triangular segments more broadly thickened so that the normally thin central area is much reduced.

Hypotype: U.S.N.M. 564299, Lodo 67.

Distribution: Locally present in Units 3 and 4 (Lower and Middle Eocene). Originally recorded from the lower Lutetian (Middle Eocene) of Donzacq, France, and recorded from the Middle Eocene of Germany.

Micrantholithus pinguis Bramlette and Sullivan, **new species**
Plate 8, figure 13a–b

Description: Pentaliths star-shaped, small for the genus but ranging in thickness from one-third to almost equal the total diameter. Adjacent sides of the marginally concave segments form rather short rays. Overall diameter 7–12μ.

Remarks: The thickness of these relatively small pentaliths is one of the more distinctive features and is evident even in plan view, from the birefringence, relief, and depth in focusing.

Holotype: U.S.N.M. 564300, Lodo 31.

Distribution: Locally common throughout Unit 2 (Paleocene).

Micrantholithus truncus Bramlette and Sullivan, **new species**
Plate 9, figure 9a–b

Description: Pentaliths with some thickening of the central area on one side, forming a superimposed small star, the tips of which extend to near the middle of the

cordate segments. The median part near the outer margin of the segments is usually thin. Overall diameter 12–18μ.

Remarks: The superimposed central star and general outline appearing as truncated rays of a star are characteristic of this species.

Holotype: U.S.N.M. 564301, Lodo 31.

Distribution: Locally present throughout Unit 2 (Paleocene).

Micrantholithus vesper Deflandre
Plate 9, figure 10a–b

Micrantholithus vesper DEFLANDRE, 1950, C. R. Acad. Sci., vol. 231, p. 1157, text-figs. 5–7. – DEFLANDRE, 1954, *in* DEFLANDRE AND FERT, Ann. Pal., vol. 40, p. 166, pl. 13, fig. 17; text-figs. 5, 115–116. – MARTINI, 1958, Senckenbergiana leth., vol. 39, no. 5–6, pp. 356–357, pl. 1, fig. 3a–c.

Remarks: The pentaliths recorded here appear typical of this large but thin species. They are seldom found except as the easily separated segments, and are partially separated in figure 10.

Hypotype: U.S.N.M. 564302, Lodo 67.

Distribution: Locally present in Units 3 and 4 (Lower and Middle Eocene). Originally recorded from the lower Lutetian (Middle Eocene) of Donzacq, France, and recorded from the Middle and Upper Eocene of Germany.

INCERTAE SEDIS

Genus Chiphragmalithus Bramlette and Sullivan, new genus

Form basket-like, with cross septa dividing it into quadrants. The septa, especially at the center, extend higher than the side wall, and this wall slopes down to an open basal area which is commonly closed in *C. cristatus*.

Although the exact form can be determined only by varying the orientation, the described species are easily recognized by distinctive features seen in side view or the more usual plan view. It appears somewhat like an ortholithid in polarized light, although this is evidently due to the crystallites being arranged nearly perpendicular to the plan view, with their optic C-axis nearly vertical, rather than being formed of a single unit of calcite.

Development from a form such as *Zygolithus dubius* or, more probably, *Z. protenus* seems indicated by similarities in side view (compare pl. 6, fig. 14a, and pl. 10, figs. 3, 9, and 10) and also by the peculiar orientation of component crystallites evident between crossed nicols.

Type species: Chiphragmalithus calathus Bramlette and Sullivan, n. sp.

Chiphragmalithus acanthodes Bramlette and Sullivan, new species
Plate 10, figures 1a–b, 2–6

Description: Specimens elliptical, height of rim equal to about one-quarter the greatest diameter, rim flaring distally, with the periphery in most specimens showing well-developed barbs hooking sinistrally in distal view. Central opening transversely spanned by septa forming an X-shaped structure. Septa higher than the rim, especially toward the center, and show through the rim conspicuously in side view. Length 9–13μ.

Remarks: Specimens that are typical of this species except for a higher and more flaring rim resemble *Chiphragmalithus cristatus* and indicate development into that species.

Holotype: U.S.N.M. 564303, Domengine OC-2.

Paratypes: U.S.N.M. 564304–08, Domengine OC-2.

Distribution: Locally present in Units 4 and 5 (Middle Eocene). Occurs in the Tyus member of the Weches Formation (Middle Eocene) of Sabine River, Texas, and in the Middle Eocene of the Carrière de Nousse, in southwestern France.

Chiphragmalithus calathus Bramlette and Sullivan, new species
Plate 10, figures 7a–b, 8–10

Description: Specimens ranging from circular or slightly quadrate to slightly elliptical in plan view. Rim thin, its height one-half to equal to the greatest diameter, flaring somewhat distally, with the periphery commonly showing slight barbs hooking sinistrally in distal view. Central opening transversely spanned by an X-shaped structure formed by septa, which are slightly higher than the rim and are conspicuous through the rim in side view. Length 6–9μ.

Remarks: This form differs from *Chiphragmalithus acanthodes* in being smaller but relatively higher and more nearly circular in plan view and in having less conspicuous peripheral barbs.

Holotype: U.S.N.M. 564309, Lodo 36.

Paratypes: U.S.N.M. 564310, Lodo 34, and 564311–12, Lodo 36.

Distribution: Locally present throughout Unit 3 (Lower Eocene), more common near the base. Occurs also in the London Clay (Lower Eocene) of England.

Chiphragmalithus cristatus (Martini)
Plate 10, figures 11a–c, 12–13

Trochoaster cristatus MARTINI, 1958, Senckenbergiana leth., vol. 39, no. 5–6, p. 368, pl. 5, fig. 26a–b. – STRADNER, 1959, Erdoel-Zeitschr., no. 12, p. 481, text-figs. 56, 58.

Remarks: Specimens in a sample obtained from Martini appear identical with our form, but various orientations indicate the characters typical of *Chiphragmalithus* rather than of *Trochoaster* Klumpp (1953, pp. 384–385). The species is represented in the California samples by a large number of well-preserved specimens. It is circular to somewhat quadrate in plan view, with the rim greatly flaring distally. The rim is ornamented by two or three thickened ridges in each quadrant, extending into a lobate periphery. The central area is spanned by cross septa which tend to curve dextrally in distal view, and the central opening is small and commonly obscured by the septa in this view (pl. 10, fig. 11a) but apparent on the proximal side. In side view the septa are seen to be about twice as high in the center as at their junction with the rim. Evidence of development from *C. acanthodes* was mentioned in the discussion of that species. Diameter 8–16μ.

Hypotypes: U.S.N.M. 564313–15, Canoas OC–4.

Distribution: Locally present in Units 4, 5, and 6 (Middle Eocene). Recorded from the Middle Eocene of Germany and Austria. Also occurs in the Middle Eocene at Gibret, in southwestern France.

Chiphragmalithus? quadratus Bramlette and Sullivan, new species
Plate 10, figures 14a–b, 15

Description: Specimens large, with four long, acutely tipped rays, usually slightly offset at the center and not consistently equal in length. Webbing with thin and irregular margin connects the rays to form a base, although this may be poorly developed or lacking in some specimens. Side view shows rays tapering outward from thick central section. Diameter 11–23μ.

Remarks: This form appears closely related to "*Trochoaster*" *swasticoides* Martini (1958, pp. 368–369), differing only in having nearly straight rather than hook-ended rays as in his species. Neither form seems to be related to *Trochoaster* Klumpp (1953, pp. 384–385), although that genus was poorly described, and both are more similar to *Chiphragmalithus*, particularly to *C. cristatus*. The differences, however, will probably warrant a new generic assignment for this species after the type species of *Trochoaster* has been restudied.

Holotype: U.S.N.M. 564316, Canoas GC–2.

Paratype: U.S.N.M. 564317, Canoas GC–3.

Distribution: Locally present in the upper part of Unit 5 and common in Unit 6 (Middle Eocene). Occurs in the Middle Eocene of Trinidad and Germany.

Genus Clathrolithus Deflandre, 1954

"Corpuscules calcaires assez épais, de contour arrondi, percés de trous formant une sorte de réticulum à mailles hexagonales ou polygonales arrondies."

The side view shows an increase in height toward the center of the mesh of ridges on the distal side of the flat basal plate. As this is an ortholithid form consisting of a single unit of calcite, no birefringence is shown between crossed nicols in the usual flat orientation, the optic C-axis thus being perpendicular.

Type species: Clathrolithus ellipticus Deflandre, 1954.

Clathrolithus ellipticus Deflandre
Plate 10, figures 16a–b, 17

Clathrolithus ellipticus Deflandre, 1954, *in* Deflandre and Fert, Ann. Pal., vol. 40, p. 169, pl. 12, fig. 19; pl. 14, fig. 7; text-figs. 123–124.

Remarks: This species in the Lodo section appears to be identical with topotype specimens, except for being slightly larger (9–15μ in length). The specimens are planoconvex in side view (pl. 10, fig. 17), with the ridges that form the honeycomb-like reticulum not perpendicular to the flat, proximal surface but curving toward one end.

Hypotypes: U.S.N.M. 564318, Lodo 19, and 564319, Lodo 62.

Distribution: Locally common in Unit 2 (Paleocene) and sporadic in Units 3 and 4 (Lower and Middle Eocene). Occurs in the Weches Formation (Middle Eocene) of Sabine River, Texas, and in the Bashi Formation (Paleocene or Lower Eocene) of Alabama; originally recorded from the lower Lutetian (Middle Eocene) of Donzacq, France.

Clathrolithus minutus Bramlette and Sullivan, new species
Plate 10, figure 18

Description: Plates small, elliptical, planoconvex, with ridges forming a honeycomb-like reticulum of usually 16–20 hexagonal cellules. Length 6–7μ.

Remarks: This species is easily distinguished from *Clathrolithus ellipticus* by the distinctly smaller size of the plates and their much finer mesh. In side view the convex surface is not as highly arched as in the larger species.

Holotype: U.S.N.M. 564320, Lodo 67.

Distribution: Locally sporadic in Units 3 and 4 (Lower and Middle Eocene). Sparse in the Weches Formation (Middle Eocene) of Sabine River, Texas, and in the lower Lutetian (Middle Eocene) of Donzacq, France.

Genus Discoaster Tan Sin Hok, 1927

Various stellate to multiradiate discoidal forms (asteroliths) are assigned to this genus. The subdivision, apparently subgeneric, proposed by Tan Sin Hok (1927, p. 117) as *Heliodiscoaster* to distinguish the more discoidal

forms consisting of many closely joined rays is not followed here. An arbitrary delimitation based on such a difference is difficult to apply, as variations in some of the species would bridge any such subdivision.

The central area in many species bears a stem, usually on one side of the disc only, and in some species, a less prominent stem also occurs on the other side of the disc. In other species the stem is broad and less elongate, like a bulla. In still other species, no comparable central process is developed, and in some otherwise well characterized species, such as *Discoaster multiradiatus*, it is not present in all specimens. Species with curved rays have this curvature sinistral as viewed on the side with stem. The significance of this feature is not now apparent, but it seems consistent for all known species with curved rays.

The asteroliths have the typical ortholithid character of being formed as a single unit of calcite, including the stem. The optic C-axis of the calcite unit is consistently perpendicular to the plane (or curved surface) which includes the rays, and thus in plan view between crossed nicols the specimens lack birefringence but show the maximum relief or refringence.

Most species show some variation (usually about 25 per cent) in the number of rays but have features otherwise sufficiently constant to permit identification with assurance in widely separated regions. Certain other species or groups of closely related forms, especially some in the Middle Eocene, show much variation, and consistent specific characters are questionable and difficult to determine. A group of such forms is illustrated (pl. 13, figs. 1–5) but left undescribed. The similarities and differences are difficult to evaluate, even with many such specimens, because of the plexus of intergrading features. Unfortunately, new species have been described from among such variable forms without abundant specimens for study.

Discoaster barbadiensis Tan Sin Hok
Plate 11, figure 2

"Crystalloids," JUKES-BROWNE AND HARRISON, 1892, Quart. Jour. Geol. Soc. London, vol. 48, p. 178, text-figs. 4–6.
Discoaster barbadiensis TAN SIN HOK, 1927 (part), Jaarb. Mijnw. Ned. Oost-Indië, p. 119. – BRAMLETTE AND RIEDEL, 1954, Jour. Pal., vol. 28, no. 4, pp. 398–399, pl. 39, fig. 5a–b. – MARTINI, 1958, Senckenbergiana leth., vol. 39, no. 5–6, p. 366, pl. 5, fig. 24a–c.

Remarks: The specimens found here and elsewhere show that this species is quite variable in robustness. Because the robustness of associated species in the same sample is often similar, this variation seems to be due to the amount of calcium carbonate available in surface waters or to diagenetic additions of calcite. Asteroliths such as that illustrated here are near the average, but their features are more obscure in specimens heavy with excess calcite.

Hypotype: U.S.N.M. 564321, Lodo 76.

Distribution: Locally present in Unit 3 (Lower Eocene) and common in Units 4, 5, and 6 (Middle Eocene). Common throughout the Eocene of many regions.

Discoaster binodosus Martini
Plate 11, figure 1a–b

Discoaster binodosus binodosus MARTINI, 1958, Senckenbergiana leth., vol. 39, no. 5–6, p. 362, pl. 4, fig. 18a–b.

Remarks: Some specimens included here have some or all of their rays truncated, or even slightly bifurcated as in Martini's (1958) *Discoaster binodosus hirundinus*. The group as a whole, however, compares well with the nominate subspecies, and the subspecific distinction seems of doubtful value here.

Hypotype: U.S.N.M. 564322, Lodo 33.

Distribution: Locally present throughout most of Unit 3 (Lower Eocene). Recorded from the Eocene of Germany, and occurs in the London Clay (Lower Eocene) of England.

Discoaster cruciformis Martini
Plate 11, figure 5a–b

Discoaster cruciformis MARTINI, 1958, Senckenbergiana leth., vol. 39, no. 5–6, pp. 357–358, pl. 2, fig. 9a–b.

Remarks: This species seems to be constantly four-rayed, and it differs from *Discoaster tribrachiatus* not only in the number of rays but also in its smaller and more uniform size and in the usual slight enlargement at the tips of the rays.

Hypotype: U.S.N.M. 564323, Lodo 100.

Distribution: Locally present in Units 3 and 4 (Lower and Middle Eocene). Recorded from the Middle Eocene of Germany, and occurs in the lower Lutetian (Middle Eocene) of Donzacq, France.

Discoaster deflandrei Bramlette and Riedel
Plate 11, figure 4a–b

Discoaster deflandrei BRAMLETTE AND RIEDEL, 1954, Jour. Pal., vol. 28, no. 4, pp. 399–400, pl. 39, fig. 6; text-fig. 1a–c. – MARTINI, 1958, Senckenbergiana leth., vol. 39, no. 5–6, pp. 363–364, pl. 5, fig. 23a–c.

Remarks: Specimens such as that illustrated here, though not identical with the holotype, seem to belong to this variable species.

Hypotype: U.S.N.M. 564324, Lodo 45.

Distribution: Locally present in Unit 3 (Lower Eocene). Occurs in the Eocene and more commonly in the Oligocene of many regions.

Discoaster delicatus Bramlette and Sullivan, **new species**
Plate 11, figure 3

Description: Asteroliths discoidal, very thin and delicate, with 30–50 rays joined throughout their length, commonly obscure except near the margin. Central area normally somewhat raised on one side, forming a ring around a depressed center. Diameter 10–16μ.

Remarks: Although this species differs here from *Discoaster multiradiatus* s. l. in having a greater number of rays, it varies considerably and may be difficult to differentiate elsewhere.

Holotype: U.S.N.M. 564325, Lodo 7.

Distribution: Locally common in Unit 1 (Paleocene), and sporadic and very rare in Units 2 and 3 (Paleocene and Lower Eocene).

Discoaster diastypus Bramlette and Sullivan, **new species**
Plate 11, figures 6–8

Description: Asteroliths with 9–16 sharply pointed rays, joined through most of their length and curving sinistrally as viewed from the side with the larger part of the stem. Rays asymmetric, with a ridge forming the thick or high part along the convex curving side. Central area pierced by a heavy column (stem) somewhat larger on one side, with both ends depressed or concave. Diameter 11–20μ.

Remarks: Some specimens with fewer rays than average and with the stem less developed on one side somewhat resemble *Discoaster lodoensis* and suggest relationship between the two species.

Holotype: U.S.N.M. 564326, Lodo 23.

Paratypes: U.S.N.M. 564327, Lodo 33, and 564328, Lodo 36.

Distribution: Locally common in the lower part and sporadic through the rest of Unit 3 (Lower Eocene). Occurs in Bolli's *Globorotalia rex* Zone (basal Eocene) of Trinidad, and in the Lower Eocene at Louer (Landes), France.

Discoaster aff. **D. diastypus** Bramlette and Sullivan
Plate 11, figures 9–10

Remarks: This form seems to differ from *Discoaster diastypus* only in having the rays nearly straight rather than distinctly curved. Although intermediate forms suggest that it is only a variant of the species, it is here recorded separately pending study of similar forms occurring elsewhere.

Hypotypes: U.S.N.M. 564329, Lodo 23, and 564330, Lodo 83.

Distribution: Locally common in the lower part of Unit 3 (Lower Eocene). Occurs in the Bashi Formation (Paleocene or Lower Eocene) of Alabama.

Discoaster distinctus Martini
Plate 11, figures 11–13

Discoaster distinctus MARTINI, 1958, Senckenbergiana leth., vol. 39, no. 5–6, p. 363, pl. 4, fig. 17a–b.

Remarks: The name of this species seems rather inappropriate for the California specimens as they are highly variable and difficult to delimit. Many of those included here, nevertheless, compare well with specimens in type material obtained from Martini. The paired nodes toward the tips of the rays are conspicuous on most specimens but much less so on some, as shown by a few of the rays in figure 11, plate 11. These nodes, however, together with the character of the bifurcating tips, help to distinguish this species from many somewhat similar forms.

Hypotypes: U.S.N.M. 564331–32, Lodo 77, and 564333, Domengine OC–1.

Distribution: Locally present in Units 3–6 (Lower and Middle Eocene). Common in the Eocene of many regions; recorded from the Middle Eocene of Germany.

Discoaster elegans Bramlette and Sullivan, **new species**
Plate 11, figure 16a–b

Description: Asteroliths with 11–15 pointed rays, joined through most of their length and concentrically lined. Central area with a pronounced stem on the concave side. Diameter 11–21μ.

Remarks: This more delicate and concentrically ornamented form commonly occurs with the more common and rather variable Eocene species *Discoaster barbadiensis*. When more heavily calcified, the concentric lines become less distinct, and the specimens are difficult to distinguish from that species. The intermediate forms are few, however, and two distinct groups seem to be represented.

Holotype: U.S.N.M. 564334, Lodo 68.

Distribution: Locally present in Units 3–6 (Lower and Middle Eocene). Occurs in the Eocene of many regions.

Discoaster falcatus Bramlette and Sullivan, **new species**
Plate 11, figures 14a–b, 15

Description: Asteroliths with 7–10, commonly 9, curving rays joined through half their length. Rays asymmetric, with a ridge near the convexly curving side and a slight thickening of the other edge of the ray, resulting in a thinner central part. Central boss small but higher on the side showing the sinistral curvature of the rays. Diameter 11–19μ.

Remarks: In the lowermost Lodo occurrence (Sample 7) of this species, the asteroliths are more delicate than normal, with 7 rather than 9 rays common and with a smaller central knob (pl. 11, fig. 15). Typical forms of this species show some similarity to *Discoaster limbatus*, especially to less ornate variants of that species. *D. lodoensis* may have evolved from this species, as similarities are evident and their range relations seem to suggest it.

Holotype: U.S.N.M. 564335, Lodo 22.

Paratype: U.S.N.M. 564336, Lodo 7.

Distribution: Locally common in Units 1 and 2 (Paleocene) and rare throughout Unit 3 (Lower Eocene). Occurs in the Bashi Formation (Paleocene or Lower Eocene) of Alabama, in Bolli's *Globorotalia rex* Zone (basal Eocene) of Trinidad, and in the Paleocene 2.95 km. south of Gan, France.

Discoaster germanicus Martini
Plate 11, figure 17

Discoaster germanicus MARTINI, 1958, Senckenbergiana leth., vol. 39, no. 5–6, pp. 360–361, pl. 3, fig. 15a–b.
Discoaster plebeius MARTINI, 1958, Senckenbergiana leth., vol. 39, no. 5–6, p. 361, pl. 3, fig. 16a–b.

Remarks: The tips of the rays of the specimens recorded here are variable, some with small nodes, some without, some slightly bifurcating, some truncate, and many intermediate. They seem, however, to represent only one species. Such variations occur also in topotype material of *Discoaster germanicus* and *D. plebeius*. Distinction between the two species is difficult and is not attempted here. Its smallness and almost parallel-sided rays help to distinguish it from similar forms.

Hypotype: U.S.N.M. 564337, Lodo 107.

Distribution: Locally present throughout Units 3 and 4 (Lower and Middle Eocene). Recorded from the Middle Eocene of Germany.

Discoaster helianthus Bramlette and Sullivan, new species
Plate 11, figure 18a–b

Description: Asteroliths sunflower-shaped, with 13–14 straight-radiating rays joined through more than half their length and having rounded to somewhat pointed tips. Rays have thickened borders and radiate from a central boss that is very little raised but of large diameter, especially on one side. Diameter 7–15μ.

Remarks: This rather distinctive form shows considerable variation in size, and the illustrated specimen, though otherwise typical, is larger than average.

Holotype: U.S.N.M. 564338, Lodo 6+1.

Distribution: Locally common in Unit 1 (Paleocene); sporadic and very rare (reworked?) specimens in Unit 3 (Lower Eocene). Occurs in the Nanafalia Formation (Paleocene) of Alabama, in the type Thanetian of England, and in the Paleocene 2.95 km. south of Gan, France.

Discoaster lenticularis Bramlette and Sullivan, new species
Plate 12, figures 1a–b, 2

Description: Asteroliths discoidal, small but centrally thick, with 20–26 rays joined throughout their length, curving sinistrally toward the periphery as viewed from the stem (boss) side and having bluntly rounded tips. Central area of one side with a small, low boss, depressed in the center. Diameter 8–12μ.

Remarks: This small species differs from other many-rayed discoasters in the relatively great increase in thickness toward the center and in the marked curvature of the rays, which are joined out to the periphery.

Holotype: U.S.N.M. 564339, Lodo 31.

Paratype: U.S.N.M. 564340, Lodo 31.

Distribution: Locally present in Unit 2 (Paleocene); sporadic and very rare (reworked?) specimens in Unit 3 (Lower Eocene). Occurs in the Bashi Formation (Paleocene or Lower Eocene) and in the Clayton formation (Paleocene) of Alabama, and in the Paleocene 2.95 km. south of Gan, France.

Discoaster limbatus Bramlette and Sullivan, new species
Plate 12, figure 3a–b

Description: Asteroliths with 8–11, usually 9, rays joined through about half their length, curving slightly and commonly ornamented by small nodes toward the tips. Rays thickened around the margin and along the ridge or high part of each ray, which is on the convex curving side. Ridges merge centrally into a boss of large diameter, which, however, is somewhat elevated on only one side of the asterolith. Diameter 11–15μ.

Remarks: This distinctive form differs from *Discoaster falcatus* in having a larger central boss, rays commonly ornamented with nodes toward the tips, and more thickened or limbate ridges and margins. Dark radiating lines appear within the central boss on focusing down into the specimen. These are apparently due to an inward continuation of ray structure beneath the surface boss. Some specimens show similarities to *D. helianthus*, but the latter has straight rays of more uniform width and with rounded tips.

Holotype: U.S.N.M. 564341, Lodo 31.

Distribution: Locally common throughout Unit 2 (Paleocene). Occurs in the Bashi Formation (Paleocene or Lower Eocene) of Alabama.

Discoaster lodoensis Bramlette and Riedel
Plate 12, figures 4a–b, 5

Discoaster lodoensis BRAMLETTE AND RIEDEL, 1954, Jour. Pal., vol. 28, no. 4, p. 398, pl. 39, fig. 3a–b. – MARTINI, 1958, Senckenbergiana leth., vol. 39, no. 5–6, pp. 366–367, pl. 6, fig. 28a–d. – STRADNER, 1959, Erdoel-Zeitschr., no. 12, p. 478, text-figs. 14–16, 19–20.
Discoaster currens STRADNER, 1959, Erdoel-Zeitschr., no. 12, pp. 477–478, text-figs. 12–13, 18.

Remarks: A restudy of type material shows a stem on both sides of most specimens, though distinctly more prominent on one side. The rays curve sinistrally when viewed from the side with the more prominent stem. Some forms with very short rays and little stem (pl. 12, fig. 5) appear to be only occasional variants of the species. Rare aberrant forms with only three rays and very little stem development are associated with normal specimens and were called *Discoaster currens* by Stradner (1959), although he mentioned their possible relationship to *D. lodoensis*. This widespread species is quite distinctive despite the range in size and number of rays.

Hypotypes: U.S.N.M. 564342, Domengine OC–2, and 564343, Lodo 41.

Distribution: Locally common throughout Units 3 and 4 (Lower and Middle Eocene) and rare in Units 5 and 6 (Middle Eocene). Common in the Lower and Middle Eocene of many regions.

Discoaster martinii Stradner
Plate 12, figure 12a–c

Discoaster pentaradiatus Tan Sin Hok. – MARTINI, 1958, Senckenbergiana leth., vol. 39, no. 5–6, p. 359, pl. 3, fig. 12a–b.
Discoaster martinii STRADNER, 1959, Erdoel-Zeitschr., no. 12, pp. 479–480, text-figs. 45, 47.

Remarks: The California specimens are smaller but otherwise like those from the Aragon Formation of Mexico, from which Stradner (1959) described the species, and resemble his figure 47. His figure 45, however, seems to represent a bizarre and unusual variant, as only one such specimen was observed in our Aragon material among many specimens more like that illustrated here. The asteroliths have five or rarely four rays, with strongly bifurcated and turned-down tips, which extend out at nearly right angles to the rays. The central area is large, and the rays are normally parallel-sided and do not show nodes, nor are the bifurcated tips normally as extended as shown in Stradner's figure 45.

This species differs from *Discoaster pentaradiatus* in being much larger and more robust and in the character of the bifurcated tips of the rays. Examination of material from which Martini (1958) identified this form as *D. pentaradiatus* supports Stradner's view that Martini's form is synonymous with his new species. The California specimens are about 13 to 14μ in diameter.

Hypotype: U.S.N.M. 564344, Canoas GC–3.

Distribution: Locally present in Unit 6 (Middle Eocene). Recorded from the Middle Eocene of Germany.

Discoaster mediosus Bramlette and Sullivan, new species
Plate 12, figures 7a–b, 8

Description: Asteroliths large, having 8–10 small, nearly parallel-sided rays with rounded to somewhat pointed tips, radiating from a large central disk, one side of which has ridges intermediate to the rays and a low central knob. Diameter 11–21μ, usually about 17μ.

Remarks: This species is distinguished by its large central disk and small, nearly parallel-sided rays. The intermediate ridges on the disk are usually distinct, though less so when seen through the specimen from the opposite side.

Holotype: U.S.N.M. 564345, Lodo 22.

Paratype: U.S.N.M. 564346, Lodo 20.

Distribution: Locally common in Unit 2 (Paleocene) and rare in the base of Unit 3 (Lower Eocene).

Discoaster aff. D. mediosus Bramlette and Sullivan
Plate 12, figure 9

Remarks: Forms so designated are not typical in that they are distinctly smaller, ranging from 8 to 13μ in diameter, and have fewer rays, usually 7–9, which are longer in relation to the central disk than in *Discoaster mediosus*. Possibly these sparse forms are only immature specimens, but they are consistently smaller and their range is higher than that of the typical form.

Hypotype: U.S.N.M. 564347, Lodo 68.

Distribution: Locally present in Unit 3 (Lower Eocene). Occurs in the Bashi Formation (Paleocene or Lower Eocene) of Alabama.

Discoaster multiradiatus Bramlette and Riedel
Plate 12, figure 10

Discoaster multiradiatus BRAMLETTE AND RIEDEL, 1954, Jour. Pal., vol. 28, no. 4, p. 396, pl. 38, fig. 10.

Remarks: Relatively few specimens typical of this species were observed in the Lodo samples compared with abundant specimens of the associated varietal form provisionally recorded as *Discoaster multiradiatus* var. The knob on many specimens is indistinct or lacking, as in topotype material.

Hypotype: U.S.N.M. 564348, Lodo 30.

Distribution: Locally rare and sporadic in Units 2 and 3 (Paleocene and Lower Eocene) but very common in the Paleocene strata of the Lodo in nearby localities. Common in the Paleocene of many regions.

Discoaster multiradiatus Bramlette and Riedel var.
Plate 12, figure 11a–b

Remarks: This form differs from the typical species in being more delicate, with rays not thickened but rather thin along the middle and somewhat thicker at the borders, and showing a faint concentric ornamentation. The central knob varies in its degree of development and is lacking in some specimens, as in the typical form. *Discoaster multiradiatus* s. s. is rare in this Lodo section, and this more delicate form might be considered a subspecies. It seems probable, however, that it merely represents less heavily calcified specimens, as some gradation is evident and only the typical form is common in equivalent strata in the Lodo within a few miles. Both forms and intermediate ones commonly occur together in the Paleocene of France.

Hypotype: U.S.N.M. 564349, Lodo 30.

Distribution: Locally common in Unit 2 (Paleocene) and rare through most of Unit 3 (Lower Eocene). Occurs in the Bashi Formation (Paleocene or Lower Eocene) of Alabama.

Discoaster nonaradiatus Klumpp
Plate 12, figures 13–15

Discoaster nonaradiatus KLUMPP, 1953, Palaeontographica, vol. 103, pt. A, p. 383, text-fig. 3 (5). – MARTINI, 1958, Senckenbergiana leth., vol. 39, no. 5–6, p. 364, pl. 4, fig. 21a–b.

Remarks: The California specimens compare well with those identified by Martini and seem to agree with Klumpp's diagrammatic figure. The tips of the rays bifurcate broadly, almost joining to form an entire margin. Strongly curving short ridges in the central area, as in *Discoaster mirus*, are rather common though somewhat obscure (pl. 12, fig. 13); some specimens show ornamentation similar to that of *D. septemradiatus* but differ from that species in the nearly closed margin. Specimens with eight rays are more common than those with nine.

Hypotypes: U.S.N.M. 564350–51, Canoas OC–3, and 564352, Canoas OC–4.

Distribution: Locally present in Units 4, 5, and 6 (Middle Eocene). Recorded from the Middle Eocene of Germany, and occurs in the Weches Formation (Middle Eocene) of Sabine River, Texas, and in the Middle Eocene of France.

Discoaster septemradiatus (Klumpp)
Plate 12, figures 16–17

Agalmatoaster septemradiatus KLUMPP, 1953, Palaeontographica, vol. 103, pt. A, p. 384, text-fig. 4(1). – MARTINI, 1958, Senckenbergiana leth., vol. 39, no. 5–6, pp. 364–365, pl. 4, fig. 20a–b.

Remarks: Although the tips of the rays of this form vary in degree of bifurcation, the ornamentation in the form of ridges between and on the rays is distinctive. The California specimens compare well with those identified by Martini as this species, and seem to agree with Klumpp's figure and description.

Hypotypes: U.S.N.M. 564353, Lodo 58, and 564354, Lodo 71.

Distribution: Locally present in Units 3–6 (Lower and Middle Eocene). Recorded from the Middle Eocene of Germany.

Discoaster sublodoensis Bramlette and Sullivan, new species
Plate 12, figure 6a–b

Description: Asteroliths small, with 5 (or less commonly 6) sharply pointed rays joined through about half their length and straight-radiating in the separated outer part. High part of each ray forms a ridge along one side, which turns sharply counter-clockwise near the periphery, as viewed from the stem side, and is usually faint to obscure from there to the tip. Central area with a small stem on one side. Diameter 8–13μ.

Remarks: This species differs from the smallest specimens of *Discoaster lodoensis*, which approach the same size, in having straight-radiating rays with sharply angled ridges, obscure on the outer half, rather than the distinctly curved rays and ridges of the larger species. It commonly occurs in large numbers with few or no associated *D. lodoensis*.

Holotype: U.S.N.M. 564355, Canoas OC–4.

Distribution: Locally present in Units 4 and 5 (Middle Eocene) but abundant only in Unit 5. Occurs in the Weches Formation (Middle Eocene) of Sabine River, Texas, and in the Middle Eocene at Gibret, France.

Discoaster tribrachiatus Bramlette and Riedel
Plate 13, figures 6a–b, 7–13

Discoaster tribrachiatus BRAMLETTE AND RIEDEL, 1954, Jour. Pal., vol. 28, no. 4, p. 397, pl. 38, fig. 11. – MARTINI, 1958, Senckenbergiana leth., vol. 39, no. 5–6, p. 357, pl. 2, fig. 8a–b. – STRADNER, 1959, Erdoel-Zeitschr., no. 12, p. 477, text-figs. 5–6, 10. – DEFLANDRE, 1959, Rev. Micropal., vol. 2, no. 3, pp. 138–139, pl. 2, figs. 1–2.
Discoaster rotans STRADNER, 1959, Erdoel-Zeitschr., no. 12, p. 477, text-figs. 7, 11.

Remarks: This consistently three-rayed species shows much variation in the curvature of the rays as seen in side view, in the taper of the rays, and in the character of the tips. Abundant specimens show all intermediate forms between those illustrated in plate 13, figures 6–13, and some of the differences in the rays are shown by one individual. Further subdivision seems of doubtful value, and assignment to more than one taxon becomes

difficult. A topotype specimen illustrated by Deflandre (1959, pl. 2, fig. 1), and especially certain variants somewhat similar to it, resemble Deflandre's *Marthasterites*, as he has indicated. Though development from *Marthasterites* seems probable, inclusion of this whole group of variants in *Discoaster tribrachiatus* avoids difficult and apparently unnatural subdivision. Modification of the generic characterization of *Marthasterites* to include them all would eliminate its most important generic character and involve the triradiate variants of species such as *D. brouweri*.

Hypotypes: U.S.N.M. 564356–58, Lodo 33; 564359–62, Lodo 41; and 564363, Lodo 67.

Distribution: Locally common throughout Unit 3 (Lower Eocene), and especially common in the lower part. Common in the Lower Eocene of many regions, including the London Clay of England and the Ypresian of Denmark.

Discoaster spp.
Plate 13, figures 1–5

Remarks: The forms grouped together here show similarities, although the differences in certain features are such as to suggest that perhaps more than one species is represented. The intergradation among many specimens, however, makes any well-defined species difficult to recognize, and their associated stratigraphic occurrence further minimizes any value of subdivision within the group. Pending further study, one or more specific names are not proposed here.

Hypotypes: U.S.N.M. 564364, Lodo 36; 564365, Lodo 50; 564366, Lodo 54; 564367, Lodo 71; and 564368, Domengine OC–1.

Genus Discoasteroides Bramlette and Sullivan, new genus

Asteroliths having a large, terminally concave stem flaring out as radiate elements at the end.

Between crossed nicols, the difference is especially evident between the ortholithid discoasters, with stem included in the unit mass of calcite, and the heliolithid character of the large stem of *Discoasteroides*. A side view of the stem thus shows different extinction positions for its two sides, and the end view of the stem shows the extinction lines forming a cross.

Although this unusual character of the stem seems adequate as a basis for generic distinction from *Discoaster*, close relationship is indicated by forms such as *Discoaster diastypus*, the large stem of which is deeply depressed terminally, and, although not pronouncedly flaring, it also shows a slight difference in the extinction positions of the two sides.

Type species: Discoasteroides kuepperi (Stradner) = *Discoaster kuepperi* Stradner, 1959.

Discoasteroides kuepperi (Stradner)
Plate 13, figures 16a–b, 17, 18a–c, 19

Discoaster kuepperi STRADNER, 1959, Erdoel-Zeitschr., no. 12, p. 478, text-figs. 17, 21.

Remarks: This distinctive and common form in the California section is evidently that described by Stradner. Specimens are mushroom-shaped and have 8 to 10 (usually 9) rays joined through most of their length, with bluntly pointed tips. The large flaring stem has an end diameter as great as half that of the asterolith and is strongly depressed toward the center. The crystallite arrangement in the large stem is characteristic of *Discoasteroides*. An especially large variant of this form (pl. 13, fig. 17) has a smaller stem than normal and rays showing concentric lines, and thus resembles and is perhaps related to *Discoaster elegans*.

Hypotypes: U.S.N.M. 564369, Lodo 41; 564370, Lodo 52; 564371, Lodo 67; and 564372, Lodo 80.

Distribution: Locally common throughout Units 3 and 4 (Lower and Middle Eocene). Recorded from the Paleocene of Austria, and common in the Eocene of many regions.

Discoasteroides megastypus Bramlette and Sullivan, new species
Plate 13, figures 14a–d, 15a–c

Description: Asteroliths mushroom-shaped, having about 30 delicate rays, joined throughout their length, with rounded to bluntly pointed tips. Large flaring central stem has a terminal diameter about half that of the asterolith, with end depressed or concave and depression continuing as a small hole down most of the stem. Diameter 8–12μ.

Remarks: In contrast to the heavy stem, the delicate rays of this form are very difficult to see in plan view in Canada balsam. Between crossed nicols, the plan and side views of the large stem show the radiate structure of heliolithids, whereas the petals, which are like the ortholithid discoasters, show no distinct birefringence in plan view. The plan view of *Heliolithus riedeli* appears much like this species, similarly oriented, in transmitted light, but between crossed nicols the radiate petals of *H. riedeli* are quite different in their distinct birefringence and extinction cross (pl. 14, fig. 9c). The rare specimens recorded in Unit 2 include variants rather similar to some specimens of the common *Discoaster multiradiatus* with abnormally large stem, and suggest the development of *D. multiradiatus* from this species.

Holotype: U.S.N.M. 564373, Lodo 22.

Paratype: U.S.N.M. 564374, Lodo 7.

Distribution: Locally present in Unit 1 (Paleocene); sporadic and very rare occurrences in Units 2 and 3 (Paleocene and Lower Eocene).

Genus **Fasciculithus** Bramlette and Sullivan, new genus

Forms of short cylindrical shape, appearing as a bundle of short rods with two or three encircling bands suggestive of a much shortened fascis. End view appearing as a rosette of about ten elements, with one end concave and the other protruding in the central area.

Although showing marked variations, especially in the compactness or solidity of the structure with varying degrees of calcification, which tends to obscure the surface features, this form-genus is distinctive, especially between crossed nicols. The side view shows extinction positions for each side at 25° to 30° from the central axis, and the end view shows an extinction cross indicating the radial arrangement of the heliolithid group.

Type species: Fasciculithus involutus Bramlette and Sullivan.

Fasciculithus involutus Bramlette and Sullivan, new species

Plate 14, figures 1a–c, 2a–b, 3a–b, 4a–b, 5a–b

Description: Specimens of short cylindrical form, with end view appearing as a rosette of about ten rounded petals, both ends somewhat concave but with a small central knob in one end. Commonly compact, with surface ridges on cylindrical sides rather obscure. Length 5–13μ.

Remarks: Much of the variation in appearance of this species seems to be largely related to the solidity of construction by varying amounts of calcite deposition. Specimens are typically like that shown in plate 14, figure 3. Less compact specimens, such as that shown in figure 1, and some of intermediate character are less common. However, subdivision of better characterized taxa within this genus elsewhere may permit their recognition among forms here included in the broadly defined species.

Holotype: U.S.N.M. 564375, Lodo 7.

Paratypes: U.S.N.M. 564376–77, Lodo 7; 564378, Lodo 31; and 564379, Lodo 32.

Distribution: Locally common in Units 1 and 2 (Paleocene); rare and sporadic (reworked?) specimens in Unit 3 (Lower Eocene). Common in the Paleocene of many regions, including France and the type Thanetian of England.

Genus **Heliolithus** Bramlette and Sullivan, new genus

Forms consisting of two partial cones joined at truncate apices and having concave basal ends. The larger of the conical parts is more appressed or flaring and shows more distinctly the many thin radiate elements of construction.

Specimens in Canada balsam are more apparent between crossed nicols than in normal transmitted light, and the heliolithid radial arrangement of component calcite elements is especially conspicuous in end view, which shows the sharply defined cross of the extinction lines.

Type species: Heliolithus riedeli Bramlette and Sullivan.

Heliolithus riedeli Bramlette and Sullivan, new species

Plate 14, figures 9a–c, 10–11

Description: Forms with two conical-shaped parts joined at truncate apices. Conical ends vary from being similar to having one distinctly more appressed and greater in diameter of base. Thin peripheral part of concave bases showing about 20 petal-like elements; small hole present in the thick central part. Diameter 7–11μ.

Remarks: The distinct extinction cross seen in end view between crossed nicols indicates the heliolithid construction, and specimens thus observed are more conspicuous than in ordinary transmitted light. Large specimens are usually more delicate than average ones, due to the deeper concave depression of the ends, especially the larger end.

Holotype: U.S.N.M. 564380, Lodo 6+1.

Paratypes: U.S.N.M. 564381–82, Lodo 6+1.

Distribution: Locally present in Unit 1 (Paleocene); sporadic and very rare (reworked?) specimens in Unit 3 (Lower Eocene). Widespread in the Paleocene, including occurrences in the Nanafalia and Salt Mountain Formations of Alabama, the Velasco shale of Mexico, the *Globorotalia pseudomenardii* Zone of Bolli in Trinidad, the type Thanetian of England, and in the Lower Paleocene 3.2 km. south of Gan, France.

Heliolithus aff. **H. riedeli** Bramlette and Sullivan

Plate 14, figure 12

Remarks: Forms so recorded have the larger end flaring to such a degree as to approach a nearly flat disk, and the number of petal-like elements is correspondingly great, nearly double the twenty usual in the typical form. The smaller end is much reduced in size, so as to appear as a small knob, nevertheless showing the central depression.

Despite the occurrence of specimens that are somewhat intermediate between this form and typical *Heliolithus riedeli*, a distinct taxon may be represented here because in some other occurrences, this is the common form or the only one of the two present.

Distribution: Locally sporadic and very rare (reworked?) in Unit 3 (Lower Eocene), but common in the Paleocene strata of the Lodo in nearby localities. Common in the Paleocene at Belus, France.

Genus **Isthmolithus** Deflandre, 1954

"Corpuscule calcaire à claire-voie, en forme des parallélogramme allongé curviligne, divisé par des barres transversales."

The peculiar shape of the rim seems to be the distinctive feature of this hitherto monotypic genus. Additional study of *Isthmolithus recurvus* indicates some similarities and a possible relationship to *Zygolithus dubius*. The rim of both is higher than it is thick, but the strong relief of their plan view in Canada balsam also seems due to the orientation of their component crystallites. Polarized light shows that the dominant orientation is nearly perpendicular to the plan (flat) view, and this view thus shows nearly the maximum relief or refringence of the calcite in these two species of different genera.

Type species: Isthmolithus recurvus Deflandre.

Isthmolithus unipons Bramlette and Sullivan, new species

Plate 14, figures 15, 16a–b

Description: Specimens in the form of a parallelogram with rounded corners, with central opening divided by a single transverse bar. The two open areas are normally bridged by a rather obscure longitudinal bar, difficult to see except in side view, which arches above the rim and is connected to it and to the transverse bar. Length 5–7μ.

Remarks: This distinctive species has the basic parallelogram form of the genus but differs from *Isthmolithus recurvus* in having only one transverse bar and in having a longitudinal bridge. It is, however, generally scarce and small, and therefore needs more study.

Holotype: U.S.N.M. 564383, Lodo 40.

Distribution: Locally rare and sporadic in Unit 3 (Lower Eocene).

Genus Polycladolithus Deflandre, 1954

"Corpuscule calcaire polyédrique arrondi, à contour sensiblement hexagonal, constitué par des sortes de branches émanant du centre, ramifiées et anastamosées, se terminant à la surface en formant des dépressions arrondies."

Variations and the consistent sparseness of specimens make specific and generic characterizations difficult. Most forms seem to have three ridges radiating from the center, each of which bifurcates outward one or more times, as indicated in Deflandre's figured plesiotype but not evident in the holotype. Similarities between *Polycladolithus* and *Lithostromation*, and the occurrence of forms with characters intermediate between these two, require further study. Both groups are ortholithids with the optic C-axis of the single calcite units perpendicular to the flat side.

Type species: *Polycladolithus operosus* Deflandre.

Polycladolithus operosus Deflandre

Plate 14, figure 13a–c

Polycladolithus operosus DEFLANDRE, 1954, *in* DEFLANDRE AND FERT, Ann. Pal., vol. 40, p. 170, pl. 12, figs. 3–6; text-fig. 125.

Remarks: Each side of this discoidal form has three ridges radiating at equal angles from the center, each of which bifurcates twice toward the periphery. The structural patterns on each side of the disk are similar but are offset 60° from each other, as can be seen by focusing down through the specimens. The disk area between the ridges is normally thin and nearly transparent. Diameter 7–13μ.

The California specimens appear similar to Deflandre's (1954, pl. 12, fig. 6) plesiotype from Donzacq, and identical specimens were found in our Donzacq sample. The holotype, from New Zealand, appears, however, somewhat different, although the character is not entirely clear in the illustrations. Pending further study this form is recorded as *P. operosus*.

Hypotype: U.S.N.M. 564384, Lodo 67.

Distribution: Locally rare and sporadic in Units 3 and 4 (Lower and Middle Eocene). Recorded from the Upper Eocene of Oamaru, New Zealand, and the lower Lutetian (Middle Eocene) of Donzacq, France. Also present in the Weches Formation (Middle Eocene) of Sabine River, Texas.

Polycladolithus? sp.

Plate 14, figure 14

Remarks: This distinct form differs from the discoidal *Polycladolithus operosus* in having a trigonal outline and in having more complex outer bifurcation of the ridges. As in *P. operosus*, the radiating ridges on the two sides are offset and oriented at 60° to each other. Specimens are very rare here, however, and evident variations, along with some similarity to *Lithostromation*, make it seem desirable to defer a general description for the species.

Hypotype: U.S.N.M. 564385, Domengine OC–2.

Distribution: Locally rare in Unit 4 (Middle Eocene).

Genus Rhomboaster Bramlette and Sullivan, new genus

Forms with the basic symmetry of a rhombohedron but with the faces strongly depressed which, results in extended spine-like corners.

The ortholithid character, as a unit of calcite, is evident in polarized light. The edges of all sides are apparent in transmitted light, and in various orientations correspond to those of an oblate rhombohedron of calcite. This unusual form is perhaps more suggestive of an internal than an external skeletal element. The abundance of specimens and their occurrence only in association with abundant coccolithophorids, however, indicates derivation from some form of the nannoplankton, and their restricted occurrence in time and their associations disprove an inorganic origin even though the form is suggestive of some unusual habit of inorganic calcite crystal growth.

"*Discoaster*" *contortus* Stradner (1958) appears to be closely related to *Rhomboaster* but shows a peculiar contortion, as though twisted on an axis between opposite corners of the rhombic form. Topotype specimens of "*Trochoaster*" duplex Klumpp (1953) also appear to represent a related form, but the type species, *Trochoaster simplex* Klumpp (1953), is a complanate form and quite different from *Rhomboaster*.

Associated with an undescribed species of *Rhomboaster* in the Upper Cretaceous, there is a common form somewhat similar to the type species, particularly to that form illustrated in plate 14, figure 17, but differing fundamentally in being constructed of at least two units of differently oriented calcite, evident in polarized light.

Type species: *Rhomboaster cuspis* Bramlette and Sullivan.

Rhomboaster cuspis Bramlette and Sullivan, **new species**
Plate 14, figures 17–18, 19a–c

Description: Specimens with edges indicating a rhombohedral symmetry but with faces depressed, usually strongly concave, and cuspate corners extended like spines. Polarized light shows that it is composed of a unit mass of calcite.

Remarks: Normal Lodo specimens are shown in plate 14, figures 18–19. They appear in the usual orientation as one triradiate form superimposed on another. Figure 17 illustrates a form included in the species which has less depressed faces than usual and appears more like an ordinary rhomb of calcite. This variant is rare in the Lodo section but is the dominant form in equivalent strata in a nearby locality. Overall diameter 8–9μ, average 11μ.

Holotype: U.S.N.M. 564386, Lodo 22.

Paratypes: U.S.N.M. 564387, Lodo 22, and 564388, Lodo 32.

Distribution: Locally present throughout Unit 2 (Paleocene); very rare and sporadic occurrences in Unit 3 (Lower Eocene). Occurs in the Bashi Formation (Paleocene or Lower Eocene) of Alabama, and in the Paleocene of Trinidad.

Genus **Sphenolithus** Deflandre, 1952

"Sphénolithes à embase prismatique surmontée d'un cône allongé costulé; embase polygonale arrondie (en vue apicale), formée de bâtonnets calcaires rayonnant autour de son centre" (Deflandre, 1952*a*, p. 466).

Specimen in Canada balsam are distinctive and more obvious between crossed nicols than in normal light, and the elongate elements forming the spike also seem to be a part of the radiate arrangement of a heliolithid type.

Type species: *Sphenolithus radians* Deflandre.

Sphenolithus radians Deflandre
Plate 14, figures 6–7, 8a–b

Sphenolithus radians DEFLANDRE, 1954, *in* DEFLANDRE AND FERT, Ann. Pal., vol. 40, p. 163, pl. 12, figs. 36–38; text-figs. 109–112.

Remarks: The specimens recorded here appear identical with those of topotype material and Deflandre's figures 36–38. His text-figures 109–112 seem to represent more heavily calcified specimens. The base is concave owing to the absence of the radiate "elements" there, and the stem consists of unusually large ones, but the basically radiate character of the heliolithids is evident.

Hypotypes: U.S.N.M. 564389, Lodo 52, and 564390–91, Lodo 80.

Distribution: Locally common throughout Unit 3 (Lower Eocene) and also present in Units 4 and 5 (Middle Eocene). Common in the Eocene of many regions; recorded from the lower Lutetian (Middle Eocene) of Donzacq, France.

Contribution from Scripps Institution of Oceanography, La Jolla, California. New Series.

BIBLIOGRAPHY

BOLLI, H. M.
1957 – *The genera Globigerina and Globorotalia in the Paleocene—Lower Eocene Lizard Springs Formation of Trinidad, B.W.I.* U. S. Nat. Mus., Bull. 215, pp. 61–81.

BRAMLETTE, M. N.
1958 – *Significance of coccolithophorids in calcium carbonate deposition.* Geol. Soc. Amer., Bull., vol. 69, pp. 121–126.

BRAMLETTE, M. N., and RIEDEL, W. R.
1954 – *Stratigraphic value of discoasters and some other microfossils related to recent coccolithophores.* Jour. Pal., vol. 28, no. 4, pp. 385–403, pls. 38–39.

CHAMRAI, I. A., and LAZAREVA, E. P.
1956 – *Coccolithophoridae and their stratigraphic importance.* Akad. Nauk S.S.S.R., Doklady, vol. 108, pp. 711–714, 1 pl. (in Russian).

DEFLANDRE, G.
1947 – *Braarudosphaera nov. gen., type d'une famille nouvelle de coccolithophoridées actuels à éléments composites.* Acad. Sci., C. R., vol. 225, pp. 439–441.
1950 – *Observations sur les coccolithophoridés, à propos d'un nouveau type de braarudosphaeridé, Micrantholithus, à éléments clastiques.* Acad. Sci., C. R., vol. 231, pp. 1156–1158.
1952*a* *Classe des Coccolithophoridés.* In: GRASSÉ, P. P. (Ed.), *Traité de Zoologie.* Vol. 1, fasc. 1, pp. 439–470, text-figs. 339–364.
1952*b* *Sous-embranchement des flagellés.* In: PIVETEAU, J. (Ed.), *Traité de Paléontologie.* Vol. 1, pp. 99–130, text-figs. 1–150.
1959 – *Sur les nannofossiles calcaires et leur systématique.* Rev. Micropal., vol. 2, no. 3, pp. 127–152, pls. 1–4.

DEFLANDRE, G., and FERT, C.
1952 – *Sur la structure fine de quelques coccolithes fossiles observés au microscope électronique; Signification morphogénétique et application à la systématique.* Acad. Sci., C. R., vol. 234, pp. 2100–2102, 8 text-figs.

1954 – *Observations sur les coccolithophoridés actuels et fossiles en microscopie ordinaire et électronique.* Ann. Pal., vol. 40, pp. 117–176, pls. 1–15.

EHRENBERG, C. G.
1836 – K. Preuss. Akad. Wiss. Verh., Berlin, pp. 84–85.
1854 – *Mikrogeologie.* Leipzig.

GAARDER, K. R.
1954 – *Coccolithineae, Silicoflagellatae, Pterospermataceae and other forms from the "Michael Sars" North Atlantic Deep-Sea Expedition 1910.* Rept. Sci. Results "Michael Sars" North Atlantic Deep-Sea Exped. 1910, vol. 2, no. 4, pp. 3–20.

GORKA, H.
1957 – *Coccolithophoridae z górnego mastrychtu Polski środkowej.* Acta Pal. Polonica, vol. 2, pp. 235–284, pls. 1–5.

GRAN, H. H., AND BRAARUD, T.
1935 – *A qualitative study of the phytoplankton in the Bay of Fundy and the Gulf of Maine.* Jour. Biol. Board Canada, vol. 1, pp. 279–467.

HAECKEL, E.
1894 – *Systematische Phylogenie der Protisten und Pflanzen.* Leipzig: Vol. 1, p. 111.

HUXLEY, T. H.
1858 – *Appendix to Capt. Dayman's Admiralty Report "Deep-Sea soundings in the N. Atlantic Ocean made in H.M.S. Cyclops."*

ISRAELSKY, M. C.
1951 – *Foraminifera of the Lodo Formation, central California: General introduction and Part 1, Arenaceous foraminifera.* U. S. Geol. Survey, Prof. Paper 240–A, pp. 1–29, pls. 2–11.
1955 – *Foraminifera of the Lodo Formation, Central California: Part 2, Calcareous foraminifera (Miliolidae and Lagenidae, part).* U. S. Geol. Survey, Prof. Paper 240–B, pp. 31–79, pls. 12–19.

JUKES-BROWNE, A. J., AND HARRISON, J. B.
1892 – *The geology of Barbados; Part II, The Oceanic deposits.* Geol. Soc. London, Quart. Jour., vol. 48, pp. 170–226.

KAMPTNER, E.
1941 – *Die Coccolithineen der Südwestküste von Istrien.* Ann. Naturhist. Mus. Wien, vol. 51, pp. 54–149, pls. 1–15.
1948 – *Coccolithen aus dem Torton des Inneralpinen Wiener Beckens.* Österr. Akad. Wiss., Math.-Naturwiss. Kl., Sitzber., Abt. 1, vol. 157, pp. 1–16.
1949 – *Fossile Coccolithineen-Skelettreste aus dem Molukken-Archipel.* Österr. Akad. Wiss., Math.-Naturwiss. Kl., Anz., vol. 86, pp. 77–80.
1954 – *Untersuchungen über den Feinbau der Coccolithen.* Archiv Protistenk., vol. 100, no. 1, pp. 1–90, text-figs. 1–50.
1955 – *Fossile Coccolithineen-Skelettreste aus Insulinde; Eine mikropaläontologische Untersuchung.* K. Nederl. Akad. Wetensch., Verh., ser. 2, vol. 50, no. 2, pp. 1–87, pls. 1–9.
1956 – *Zur Systematik und Nomenklatur der Coccolithineen.* Österr. Akad. Wiss., Math-Naturwiss. Kl., Anz., no. 1, pp. 4–11.
1958 – *Betrachtungen zur Systematik der Kalkflagellaten, nebst Versuch einer neuen Gruppierung der Chrysomonadales.* Archiv Protistenk., vol. 103, no. 1–2, pp. 54–116.

KLUMPP, B.
1953 – *Beitrag zur Kenntnis der Mikrofossilien des Mittleren und Oberen Eozän.* Palaeontographica, vol. 103, pt. A, pp. 377–406, pls. 16–20.

LAIMING, B.
1940 – *Some foraminiferal correlations in the Eocene of San Joaquin Valley, California.* Proc. Sixth Pacific Sci. Congr., 1939, vol. 2, pp. 535–568.

LOEBLICH, A. R., AND TAPPAN, H.
1957 – *Planktonic foraminifera of Paleocene and early Eocene age from the Gulf and Atlantic Coastal Plains.* U. S. Nat. Mus., Bull. 215, pp. 173–198.

LOHMANN, H.
1902 – *Die Coccolithophoridae, eine Monographie der coccolithenbildenden Flagellaten.* Archiv Protistenk., vol. 1, pp. 89–165, pls. 4–6.

MARTINI, E.
1958 – *Discoasteriden und verwandte Formen im NW-deutschen Eozän (Coccolithophorida).* Senckenbergiana Leth., vol. 39, no. 5–6, pp. 353–388, pls. 1–6.
1959 – *Pemma angulatum und Micrantholithus basquensis, zwei neue Coccolithophoriden-Arten aus dem Eozän.* Senckenbergiana Leth., vol. 40, no. 5–6, pp. 415–421, pl. 1.

MURRAY, G., AND BLACKMAN, V. H.
1898 – *On the nature of the coccospheres and rhabdospheres.* Roy. Soc. London, Phil. Trans., vol. 190, sec. B, pp. 427–441.

NOËL, D.
1956 – *Coccolithes des terrains Jurassiques de l'Algérie.* Publ. Service Carte Géol. Algérie, new ser., Bull. 8, pp. 303–345.

PARKE, M., AND ADAMS, I.
1960 – *The motile (Crystallolithus hyalinus Gaarder & Markali) and nonmotile phases in the life history of Coccolithus pelagicus (Wallich) Schiller.* Jour. Marine Biol. Assoc. U. K., vol. 39, pp. 263–274, pls. 1–4.

SCHILLER, J.
1930 – *Coccolithineae.* In: RABENHORST, L., *Kryptogamen-Flora.* Leipzig: Vol. 10, pt. 2, pp. 89–267.

SCHWARZ, E. H. L.
1894 – *Coccoliths.* Ann. Mag. Nat. Hist., ser. 6, vol. 14, pp. 341–346.

SORBY, H. C.
1861 – *On the organic origin of the so-called crystalloids of the Chalk.* Ann. Mag. Nat. Hist., ser. 3, vol. 8, pp. 193–200.

STRADNER, H.
1958 – *Die fossilen Discoasteriden Österreichs; I.* Erdoel-Zeitschr., no. 6, pp. 178–188, text-figs. 1–38.
1959 – *Die fossilen Discoasteriden Österreichs; II.* Erdoel-Zeitschr., no. 12, pp. 472–488, text-figs. 1–77.

TAN SIN HOK
1927 – *Over de samenstelling en het ontstaan van krijt- en mergelgesteenten van de Molukken.* Mijnw. Ned. Oost-Indië, Jaarb. (1926), pp. 1–165, 16 pls.

VEKSCHINA, V. N.
1959 – *Kokkolithoforidy maastrikhtskikh otlozhenii Zapadno-Sibirkoi Nizmennosti.* Trudy SNIIGGIMS, no. 2, pp. 56–77, pls. 1–2.

WALLICH, G. C.
1860 – Ann. Mag. Nat. Hist., ser. 3, vol. 6, pp. 451–458.

EXPLANATION OF PLATES

PLATE 1

1 *Coccolithus bidens* Bramlette and Sullivan, n. sp. Distal view; fluorite replacement.

2 *Coccolithus consuetus* Bramlette and Sullivan, n. sp. a, proximal view; b, side view, drawing; c, proximal view, long axis 0° to x-nic*.

3 *Coccolithus eminens* Bramlette and Sullivan, n. sp. a, proximal view; b, side view, drawing; c, proximal view, long axis 0° to x-nic*; d, distal view, drawing.

4 *Coccolithus crassus* Bramlette and Sullivan, n. sp. a, proximal view; b, side view, drawing; c, proximal view, long axis 0° to x-nic*; d, distal view, drawing.

5 *Coccolithus expansus* Bramlette and Sullivan, n. sp. a, distal view; b, oblique view, drawing; c, side view, drawing; d, distal view, long axis 17° to x-nic*.

6 *Coccolithus gigas* Bramlette and Sullivan, n. sp. a, distal view; b, side view, drawing; c, distal view, long axis 80° to x-nic*; d, distal view, drawing.

7 *Coccolithus* aff. *C. gigas* Bramlette and Sullivan a, distal view; b, side view section, drawing; c, distal view, long axis 50° to x-nic*; d, distal view, drawing.

PLATE 2

1 *Coccolithus grandis* Bramlette and Riedel Hypotype no. 564185: a, proximal view; b, proximal view, long axis 0° to x-nic*.

2 *Coccolithus grandis* Bramlette and Riedel Hypotype no. 564184: a, distal view, fluorite replacement; b, side view, drawing; c, end view, drawing.

3 *Coccolithus grandis* Bramlette and Riedel Hypotype no. 564186, oblique view, fluorite replacement.

4 *Coccolithus solitus* Bramlette and Sullivan, n. sp. a, proximal view; b, side view, drawing; c, proximal view, long axis 0° to x-nic*.

5 *Coccolithus staurion* Bramlette and Sullivan, n. sp. Hypotype no. 564189: a, distal view; b, distal view, long axis 0° to x-nic*.

6 *Coccolithus staurion* Bramlette and Sullivan, n. sp. Holotype, no. 564188: a, distal view; b, side view, drawing; c, distal view, long axis 0° to x-nic*.

7 *Cyclolithus? robustus* Bramlette and Sullivan, n. sp. a, plan view; b, side view, drawing; c, plan view, drawing.

8 *Discolithus distinctus* Bramlette and Sullivan n. sp. Paratype no. 564192: a, proximal view; b, proximal view, long axis 30° to x-nic*.

9 *Discolithus distinctus* Bramlette and Sullivan, n. sp. Holotype, no. 564191: a, distal view; b, side view section, drawing; c, distal view, long axis 30° to x-nic*.

10 *Discolithus exilis* Bramlette and Sullivan, n. sp. a, distal view; b, side view, drawing; c, distal view, long axis 0° to x-nic*.

11 *Discolithus duocavus* Bramlette and Sullivan, n. sp. a, proximal view; b, side view, drawing; c, proximal view, long axis 12° to x-nic*; d, distal view, drawing.

PLATE 3

1 *Discolithus fimbriatus* Bramlette and Sullivan, n. sp. a, proximal view; b, side view, drawing; c, proximal view, long axis 75° to x-nic*; d, distal view, drawing.

2 *Discolithus ocellatus* Bramlette and Sullivan, n. sp. a, distal view; b, side view, drawing; c, distal view, long axis 10° to x-nic*.

3 *Discolithus panarium* Deflandre a, distal view; b, side view, drawing; c, distal view, long axis 72° to x-nic*; d, distal view, drawing.

4 *Discolithus pectinatus* Bramlette and Sullivan, n. sp. Holotype, no. 564198: a, distal view; b, distal view, long axis 20° to x-nic*.

5 *Discolithus pectinatus* Bramlette and Sullivan, n. sp. Paratype no. 564199: a, distal view; b, distal view, long axis 15° to x-nic*.

6 *Discolithus* aff. *D. planus* Bramlette and Sullivan a, distal view; b, distal view, long axis 10° to x-nic*.

7 *Discolithus planus* Bramlette and Sullivan, n. sp. a, proximal view; b, side view section, drawing; c, proximal view, long axis 20° to x-nic*.

8 *Discolithus pulcher* Deflandre a, distal view; b, side view, drawing; c, distal view, long axis 5° to x-nic*.

9 *Discolithus* aff. *D. pulcher* Deflandre Hypotype no. 564203: a, distal view, fluorite replacement; b, side view, drawing.

*Measured clockwise from either plane of crossed nicols.

*Measured clockwise from either plane of crossed nicols.

10 *Discolithus* aff. *D. pulcher* Deflandre
Hypotype no. 564204, proximal view, long axis 75° to x-nic*.

11 *Discolithus punctosus* Bramlette and Sullivan, n. sp.
a, distal view; b, side view section, drawing; c, distal view, long axis 15° to x-nic*.

12 *Discolithus rimosus* Bramlette and Sullivan, n. sp.
Paratype no. 564207: a, distal view; b, side view section, drawing; c, distal view, long axis 60° to x-nic*.

13 *Discolithus rimosus* Bramlette and Sullivan, n. sp.
Holotype, no. 564206, distal view.

14 *Discolithus solidus* Deflandre
Hypotype no. 564208: a, distal view; b, side view, drawing; c, distal view, drawing.

15 *Discolithus solidus* Deflandre
Hypotype no. 564209, proximal view.

16 *Discolithus versus* Bramlette and Sullivan, n. sp.
a, distal view; b, side view, drawing; c, distal view, long axis 20° to x-nic*; d, distal view, drawing.

PLATE 4

1 *Helicosphaera seminulum seminulum* Bramlette and Sullivan, n. ssp.
Paratype no. 564212: a, proximal view, fluorite replacement; b, side view, drawing; c, end view, drawing.

2 *Helicosphaera seminulum seminulum* Bramlette and Sullivan, n. ssp.
Holotype, no. 564211, proximal view, long axis 0° to x-nic*.

3 *Helicosphaera seminulum lophota* Bramlette and Sullivan, n. ssp.
Holotype, no. 564213: a, proximal view; b, proximal view, long axis 0° to x-nic*.

4 *Helicosphaera seminulum lophota* Bramlette and Sullivan, n. ssp.
Paratype no. 564214, proximal view, fluorite replacement.

5 *Lophodolithus reniformis* Bramlette and Sullivan, n. sp.
a, distal view, fluorite replacement; b, side view, drawing; c, distal view, drawing.

6 *Lophodolithus mochlophorus* Deflandre
a, proximal view; b, side view, drawing; c, proximal view, long axis 70° to x-nic*.

7 *Lophodolithus nascens* Bramlette and Sullivan, n. sp.
Paratype no. 564217: a, proximal view; b, side view, drawing; c, proximal view, long axis 75° to x-nic*.

8 *Lophodolithus nascens* Bramlette and Sullivan, n. sp.
Holotype, no. 564216: a, distal view; b, side view section, drawing; c, distal view, long axis 0° to x-nic*.

9 *Zygodiscus adamas* Bramlette and Sullivan, n. sp.
Holotype, no. 564237: a, proximal view; b, side view, drawing; c, proximal view, long axis 85° to x-nic*.

10 *Zygodiscus adamas* Bramlette and Sullivan, n. sp.
Paratype no. 564238: a, proximal view, long axis 90° to polarizer, lower nicol only; b, proximal view, long axis 0° to polarizer, lower nicol only; c, proximal view, long axis 70° to x-nic*.

11 *Zygodiscus sigmoides* Bramlette and Sullivan, n. sp.
a, distal view; b, side view, drawing; c, end view, drawing; d, distal view, long axis 30° to x-nic*; e, distal view, drawing.

12 *Zygodiscus plectopons* Bramlette and Sullivan, n. sp.
a, distal view; b, side view, drawing; c, end view, drawing; d, distal view, long axis 12° to x-nic*.

13 *Zygodiscus* aff. *Z. plectopons* Bramlette and Sullivan
a, proximal view; b, side view, drawing; c, proximal view, long axis 25° to x-nic*; d, proximal view, long axis 65° to x-nic*; e, proximal view, long axis 40° to x-nic*.

PLATE 5

1 *Rhabdosphaera crebra* (Deflandre)
Hypotype no. 564219.

2 *Rhabdosphaera crebra* (Deflandre)
Hypotype no. 564221, long axis 45° to x-nic.*

3 *Rhabdosphaera crebra* (Deflandre)
Hypotype no. 564220, long axis 0° to x-nic*.

4 *Rhabdosphaera inflata* Bramlette and Sullivan, n. sp.
Holotype, no. 564222: a, side view; b, side view, long axis 0° to x-nic*.

5 *Rhabdosphaera inflata* Bramlette and Sullivan, n. sp.
Paratype no. 564223.

6 *Rhabdosphaera? rudis* Bramlette and Sullivan, n. sp.
a, side view; b, slightly oblique view, drawing.

*Measured clockwise from either plane of crossed nicols.

*Measured clockwise from either plane of crossed nicols.

7 *Rhabdosphaera perlonga* (Deflandre)
a, side view; b, side view, long axis 45° to x-nic*; c, side view, long axis 0° to x-nic*.

8 *Rhabdosphaera? semiformis* Bramlette and Sullivan, n. sp.
Holotype, no. 564229.

9 *Rhabdosphaera? semiformis* Bramlette and Sullivan, n. sp.
Paratype no. 564230.

10 *Rhabdosphaera? semiformis* Bramlette and Sullivan, n. sp.
Paratype no. 564231: a, side view; b, side view, long axis 45° to x-nic*.

11 *Rhabdosphaera scabrosa* (Deflandre)
a, side view; b, side view, long axis 0° to x-nic*.

12 *Rhabdosphaera morionum* (Deflandre)
Hypotype no. 564224: a, side view; b, side view, long axis 45° to x-nic*.

13 *Rhabdosphaera morionum* (Deflandre)
Hypotype no. 564225.

14 *Rhabdosphaera tenuis* Bramlette and Sullivan, n. sp.
a, side view; b, side view, long axis 0° to x-nic*.

15 *Rhabdosphaera truncata* Bramlette and Sullivan, n. sp.
a, side view; b, side view, long axis 0° to x-nic*.

16 *Rhabdosphaera vitrea* (Deflandre)
Hypotype no. 564235, side view, fluorite replacement.

17 *Rhabdosphaera vitrea* (Deflandre)
Hypotype no. 564234.

18 *Rhabdosphaera* sp.
a, side view; b, side view, long axis 45° to x-nic*.

19 Lopadolith from Lodo 39
Side view.

20 Lopadolith from Lodo 52.
Side view.

PLATE 6

1 *Zygolithus chiastus* Bramlette and Sullivan, n. sp.
Paratype no. 564243: a, distal view; b, side view, drawing; c, end view, drawing; d, distal view, long axis 65° to x-nic*.

2 *Zygolithus chiastus* Bramlette and Sullivan, n. sp.
Holotype, no. 564242: a, proximal view; b, proximal view, long axis 52° to x-nic*.

3 *Zygolithus chiastus* Bramlette and Sullivan, n. sp.
Paratype no. 564244: a, distal view; b, distal view, long axis 75° to x-nic*.

4 *Zygolithus distentus* Bramlette and Sullivan, n. sp.
Paratype no. 564249: a, proximal view; b, proximal view, long axis 20° to x-nic*; c, distal view, drawing.

5 *Zygolithus distentus* Bramlette and Sullivan, n. sp.
Paratype no. 564250, distal view.

6 *Zygolithus distentus* Bramlette and Sullivan, n. sp.
Holotype, no. 564248: a, distal view; b, side view, drawing; c, distal view, long axis 70° to x-nic*; d, distal view, drawing.

7 *Zygolithus distentus* Bramlette and Sullivan, n. sp.
Paratype no. 564251, distal view.

8 *Zygolithus crux* (Deflandre and Fert)
Hypotype no. 564246, plan view, fluorite replacement.

9 *Zygolithus crux* (Deflandre and Fert)
Hypotype no. 564245.

10 *Zygolithus crux* (Deflandre and Fert)
Hypotype no. 564247.

11 *Zygolithus junctus* Bramlette and Sullivan, n. sp.
a, distal view; b, distal view, long axis 20° to x-nic*.

12 *Zygolithus dubius* Deflandre
Hypotype no. 564252, distal view.

13 *Zygolithus dubius* Deflandre
Hypotype no. 564254, distal view.

14 *Zygolithus dubius* Deflandre
Hypotype no. 564253: a, side view; b, side view, long axis 45° to x-nic*.

15 *Zygolithus protenus* Bramlette and Sullivan, n. sp.
a, distal view; b, distal view, long axis 45° to x-nic*.

16 *Zygrhablithus bijugatus* (Deflandre)
Hypotypes no. 564258: a, side views of two specimens; b, long axis of specimen to right 0° to x-nic*.

17 *Zygrhablithus bijugatus* (Deflandre)
Hypotype no. 564257: a, distal view, long axis 0° to polarizer, lower nicol only; b, distal view, long axis 90° to polarizer, lower nicol only; c, distal view, long axis 45° to x-nic*.

18 *Zygrhablithus bijugatus* (Deflandre)
Hypotype no. 564259, oblique view.

19 *Zygrhablithus simplex* Bramlette and Sullivan, n. sp.
Holotype, no. 564260, side view.

*Measured clockwise from either plane of crossed nicols.

*Measured clockwise from either plane of crossed nicols.

20 *Zygrhablithus simplex* Bramlette and Sullivan, n. sp. Paratype no. 564263: a, side view, with rim broken off; b, side view, long axis 45° to x-nic*.

21 *Zygrhablithus simplex* Bramlette and Sullivan, n. sp. Paratype no. 564262, distal view, fluorite replacement.

22 *Zygrhablithus simplex* Bramlette and Sullivan, n. sp. Paratype no. 564261, oblique view, fluorite replacement.

PLATE 7

1 *Coccolithites delus* Bramlette and Sullivan, n. sp. Paratype no. 564265: a, proximal view, fluorite replacement; b, side view, drawing; c, end view, drawing.

2 *Coccolithites delus* Bramlette and Sullivan, n. sp. Holotype, no. 564264: a, proximal view, long axis 0° to x-nic*; b, proximal view, long axis 45° to x-nic*.

3 *Coccolithites* aff. *C. delus* Bramlette and Sullivan Hypotype no. 564266, proximal view, fluorite replacement.

4 *Coccolithites* aff. *C. delus* Bramlette and Sullivan Hypotype no. 564267, distal view, long axis 0° to x-nic*.

5 *Coccolithites cribellum* Bramlette and Sullivan, n. sp. Holotype, no. 564268: a, distal view, lower nicol only; b, distal view, long axis 75° to x-nic*.

6 *Coccolithites cribellum* Bramlette and Sullivan, n. sp. Paratype no. 564269: a, proximal view; b, side view, drawing.

7 *Coccolithites gammation* Bramlette and Sullivan, n. sp. Holotype, no. 564271: a, proximal view; b, side view, drawing; c, proximal view, crossed nicols.

8 *Coccolithites distichus* Bramlette and Sullivan, n. sp. a, distal view; b, side view, drawing; c, distal view, long axis 45° to x-nic*.

9 *Coccolithites* sp.
Hypotype no. 564277: a, distal view, fluorite replacement; b, side view, drawing.

10 *Coccolithites* sp.
Hypotype no. 564276, distal view, long axis 0° to x-nic*.

11 *Coccolithites macellus* Bramlette and Sullivan, n. sp. Paratype no. 564274, proximal view.

12 *Coccolithites macellus* Bramlette and Sullivan, n. sp. Paratype no. 564275, distal view, long axis 35° to x-nic*.

13 *Coccolithites macellus* Bramlette and Sullivan, n. sp. Holotype, no. 564273: a, distal view; b, side view, drawing; c, distal view, long axis 45° to x-nic*; d, distal view, drawing.

14 *Coccolithites gammation* Bramlette and Sullivan, n. sp. Specimens from Donzacq, France: a, proximal view of part of a coccosphere; b, proximal view, with crossed nicols, of part of a coccosphere.

*Measured clockwise from either plane of crossed nicols.

PLATE 8

1 *Braarudosphaera bigelowi* (Gran and Braarud) Hypotype no. 564280: a, distal view; b, side view, drawing.

2 *Braarudosphaera bigelowi* (Gran and Braarud) Hypotype no. 564278, distal view of unusual specimen with large central opening, crossed nicols.

3 *Braarudosphaera bigelowi* (Gran and Braarud) Hypotype no. 564279, side view.

4 *Braarudosphaera bigelowi* (Gran and Braarud) Hypotype no. 564282, small complete specimen of 12 pentaliths.

5 *Braarudosphaera bigelowi* (Gran and Braarud) Hypotype no. 564281, distal view of specimen with *Micrantholithus*-like central star, crossed nicols.

6 *Braarudosphaera discula* Bramlette and Riedel Hypotype no. 564283: a, plan view; b, side view, drawing.

7 *Braarudosphaera discula* Bramlette and Riedel Hypotype no. 564284, distal view.

8 *Micrantholithus attenuatus* Bramlette and Sullivan, n. sp.
Holotype, no. 564285: a, plan view; b, plan view, crossed nicols.

9 *Micrantholithus attenuatus* Bramlette and Sullivan, n. sp.
Paratype no. 564286, single segment.

10 *Micrantholithus attenuatus* Bramlette and Sullivan, n. sp.
Paratype no. 564287, single segment.

11 *Micrantholithus attenuatus* Bramlette and Sullivan, n. sp.
Paratype no. 564288, single segment.

*Measured clockwise from either plane of crossed nicols.

12 *Micrantholithus* aff. *M. attenuatus* Bramlette and Sullivan
a, plan view; b, plan view, crossed nicols.

13 *Micrantholithus pinguis* Bramlette and Sullivan, n. sp.
a, plan view; b, side view, drawing.

14 *Micrantholithus basquensis* Martini
Hypotype no. 564290, a, plan view; b, side view, drawing; c, plan view, crossed nicols.

15 *Micrantholithus basquensis* Martini
Hypotype no. 564291, plan view, crossed nicols.

PLATE 9

1 *Micrantholithus concinnus* Bramlette and Sullivan, n. sp.
a, plan view; b, side view, drawing; c, plan view, crossed nicols.

2 *Micrantholithus bramlettei* Deflandre
a, plan view of common variant; b, plan view, crossed nicols.

3 *Micrantholithus crenulatus* Bramlette and Sullivan, n. sp.
Holotype, no. 564294: a, plan view; b, plan view, crossed nicols.

4 *Micrantholithus crenulatus* Bramlette and Sullivan, n. sp.
Paratype no. 564295.

5 *Micrantholithus entaster* Bramlette and Sullivan, n. sp.
Paratype no. 564297: a, plan view; b, side view, drawing; c, plan view, crossed nicols.

6 *Micrantholithus entaster* Bramlette and Sullivan, n. sp.
Paratype no. 564298.

7 *Micrantholithus entaster* Bramlette and Sullivan, n. sp.
Holotype, no. 564296: a, plan view, median focus; b, plan view, high focus.

8 *Micrantholithus flos* Deflandre
a, plan view; b, plan view, crossed nicols.

9 *Micrantholithus truncus* Bramlette and Sullivan, n. sp.
a, plan view; b, plan view, crossed nicols.

10 *Micrantholithus vesper* Deflandre
a, plan view, with segments partly separated; b, plan view, crossed nicols.

11 *Thoracosphaera* sp. from Lodo 32
Sphere oriented with buccal opening upward.

PLATE 10

1 *Chiphragmalithus acanthodes* Bramlette and Sullivan, n. sp.
Holotype, no. 564303: a, distal view; b, oblique view, drawing.

2 *Chiphragmalithus acanthodes* Bramlette and Sullivan, n. sp.
Paratype no. 564304, plan view.

3 *Chiphragmalithus acanthodes* Bramlette and Sullivan, n. sp.
Paratype no. 564306, side view.

4 *Chiphragmalithus acanthodes* Bramlette and Sullivan, n. sp.
Paratype no. 564307, proximal view, slightly oblique.

5 *Chiphragmalithus acanthodes* Bramlette and Sullivan, n. sp.
Paratype no. 564305, proximal view.

6 *Chiphragmalithus acanthodes* Bramlette and Sullivan, n. sp.
Paratype no. 564308, oblique view.

7 *Chiphragmalithus calathus* Bramlette and Sullivan, n. sp.
Holotype, no. 564309: a, distal view; b, oblique view, drawing.

8 *Chiphragmalithus calathus* Bramlette and Sullivan, n. sp.
Paratype no. 564310, plan view.

9 *Chiphragmalithus calathus* Bramlette and Sullivan, n. sp.
Paratype no. 564312, side view.

10 *Chiphragmalithus calathus* Bramlette and Sullivan, n. sp.
Paratype no. 564311, side view.

11 *Chiphragmalithus cristatus* (Martini)
Hypotype no. 564313: a, distal view; b, oblique view, drawing; c, proximal view, drawing.

12 *Chiphragmalithus cristatus* (Martini)
Hypotype no. 564315, side view, slightly oblique.

13 *Chiphragmalithus cristatus* (Martini)
Hypotype no. 564314, proximal view.

14 *Chiphragmalithus? quadratus* Bramlette and Sullivan, n. sp.
Holotype, no. 564316: a, distal view; b, side view, drawing.

15 *Chiphragmalithus? quadratus* Bramlette and Sullivan, n. sp.
Paratype no. 564317, plan view.

16 *Clathrolithus ellipticus* Deflandre
Hypotype no. 564319: a, distal view, low focus; b, distal view, high focus.

17 *Clathrolithus ellipticus* Deflandre
Hypotype no. 564318, side view.

18 *Clathrolithus minutus* Bramlette and Sullivan, n. sp.
Plan view, fluorite replacement.

PLATE 11

1 *Discoaster binodosus* Martini
a, plan view; b, side view, drawing.

2 *Discoaster barbadiensis* Tan Sin Hok

3 *Discoaster delicatus* Bramlette and Sullivan, n. sp.

4 *Discoaster deflandrei* Bramlette and Riedel
a, plan view; b, side view, drawing.

5 *Discoaster cruciformis* Martini
a, plan view; b, side view, drawing.

6 *Discoaster diastypus* Bramlette and Sullivan, n. sp.
Paratype no. 564328.

7 *Discoaster diastypus* Bramlette and Sullivan, n. sp.
Paratype no. 564327, side view.

8 *Discoaster diastypus* Bramlette and Sullivan, n. sp.
Holotype, no. 564326.

9 *Discoaster* aff. *D. diastypus* Bramlette and Sullivan
Hypotype no. 564330, side view.

10 *Discoaster* aff. *D. diastypus* Bramlette and Sullivan
Hypotype no. 564329.

11 *Discoaster distinctus* Martini
Hypotype no. 564333.

12 *Discoaster distinctus* Martini
Hypotype no. 564331.

13 *Discoaster distinctus* Martini
Hypotype no. 564332.

14 *Discoaster falcatus* Bramlette and Sullivan, n. sp.
Holotype, no. 564335: a, plan view; b, side view, drawing.

15 *Discoaster falcatus* Bramlette and Sullivan, n. sp.
Paratype no. 564336.

16 *Discoaster elegans* Bramlette and Sullivan, n. sp.
a, plan view; b, side view, drawing.

17 *Discoaster germanicus* Martini

18 *Discoaster helianthus* Bramlette and Sullivan, n. sp.
a, plan view; b, side view, drawing.

PLATE 12

1 *Discoaster lenticularis* Bramlette and Sullivan, n. sp.
Holotype, no. 564339: a, plan view; b, side view, drawing.

2 *Discoaster lenticularis* Bramlette and Sullivan, n. sp.
Paratype no. 564340.

3 *Discoaster limbatus* Bramlette and Sullivan, n. sp.
a, plan view; b, side view, drawing.

4 *Discoaster lodoensis* Bramlette and Riedel
Hypotype no. 564342: a, plan view; b, side view, drawing.

5 *Discoaster lodoensis* Bramlette and Riedel
Hypotype no. 564343, questionable short-rayed variant.

6 *Discoaster sublodoensis* Bramlette and Sullivan, n. sp.
a, plan view; b, side view, drawing.

7 *Discoaster mediosus* Bramlette and Sullivan, n. sp.
Holotype, no. 564345: a, plan view; b, side view, drawing.

8 *Discoaster mediosus* Bramlette and Sullivan, n. sp.
Paratype no. 564346.

9 *Discoaster* aff. *D. mediosus* Bramlette and Sullivan

10 *Discoaster multiradiatus* Bramlette and Riedel

11 *Discoaster multiradiatus* Bramlette and Riedel var.
a, plan view; b, side view, drawing.

12 *Discoaster martinii* Stradner
a, plan view; b, side view, drawing; c, plan view, drawing.

13 *Discoaster nonaradiatus* Klumpp
Hypotype no. 564351.

14 *Discoaster nonaradiatus* Klumpp
Hypotype no. 564352.

15 *Discoaster nonaradiatus* Klumpp
Hypotype no. 564350.

16 *Discoaster septemradiatus* (Klumpp)
Hypotype no. 564354.

17 *Discoaster septemradiatus* (Klumpp)
Hypotype no. 564353.

PLATE 13

1–5 *Discoaster* spp.
Hypotypes no. 564364, 564365, 564366, 564368, and 564367.

6 *Discoaster tribrachiatus* Bramlette and Riedel
Hypotype no. 564357: a, plan view; b, side view, drawing.

7 *Discoaster tribrachiatus* Bramlette and Riedel
Hypotype no. 564358.

8 *Discoaster tribrachiatus* Bramlette and Riedel
Hypotype no. 564359.

9 *Discoaster tribrachiatus* Bramlette and Riedel
Hypotype no. 564356.

10 *Discoaster tribrachiatus* Bramlette and Riedel
Hypotype no. 564360.

11 *Discoaster tribrachiatus* Bramlette and Riedel
Hypotype no. 564363, side view.

12 *Discoaster tribrachiatus* Bramlette and Riedel
Hypotype no. 564362, immature(?) specimen.

13 *Discoaster tribrachiatus* Bramlette and Riedel
Hypotype no. 564361, immature(?) specimen.

14 *Discoasteroides megastypus* Bramlette and Sullivan, n. sp.
Holotype, no. 564373: a, plan view; b, side view, drawing; c, plan view, crossed nicols; d, plan view, drawing.

15 *Discoasteroides megastypus* Bramlette and Sullivan, n. sp.
Paratype no. 564374: a, side view; b, side view, stem axis 0° to x-nic*; c, side view, stem axis 78° to x-nic*.

16 *Discoasteroides kuepperi* (Stradner)
Hypotype no. 564371: a, plan view; b, plan view, crossed nicols.

17 *Discoasteroides kuepperi* (Stradner)
Hypotype no. 564369, plan view.

18 *Discoasteroides kuepperi* (Stradner)
Hypotype no. 564370: a, side view; b, side view, stem axis 0° to x-nic*; c, side view, stem axis 25° to x-nic*.

19 *Discoasteroides kuepperi* (Stradner)
Hypotype no. 564372, oblique view, fluorite replacement.

PLATE 14

1 *Fasciculithus involutus* Bramlette and Sullivan, n. sp.
Paratype no. 564376: a, side view; b, side view, long axis 0° to x-nic*; c, side view, long axis 63° to x-nic*.

2 *Fasciculithus involutus* Bramlette and Sullivan, n. sp.
Paratype no. 564379: a, plan view; b, plan view, crossed nicols.

3 *Fasciculithus involutus* Bramlette and Sullivan, n. sp.
Holotype, no. 564375: a, side view; b, side view, long axis 0° to x-nic*.

4 *Fasciculithus involutus* Bramlette and Sullivan, n. sp.
Paratype no. 564377: a, plan view; b, plan view, crossed nicols.

5 *Fasciculithus involutus* Bramlette and Sullivan, n. sp.
Paratype no. 564378: a, plan view; b, plan view, crossed nicols.

6 *Sphenolithus radians* Deflandre
Hypotype no. 564390, side view, fluorite replacement.

7 *Sphenolithus radians* Deflandre
Hypotype no. 564391, side view, fluorite replacement.

8 *Sphenolithus radians* Deflandre
Hypotype no. 564389: a, side view; b, side view, long axis 0° to x-nic*.

9 *Heliolithus riedeli* Bramlette and Sullivan, n. sp.
Holotype, no. 564380: a, plan view, small side; b, oblique view, drawing; c, plan view, crossed nicols.

10 *Heliolithus riedeli* Bramlette and Sullivan, n. sp.
Paratype no. 564382, side view.

11 *Heliolithus riedeli* Bramlette and Sullivan, n. sp.
Paratype no. 564381, plan view, large side.

12 *Heliolithus* aff. *H. riedeli* Bramlette and Sullivan
Oblique view, drawing.

13 *Polycladolithus operosus* Deflandre
a, plan view; b, plan view, high focus; c, plan view, low focus; d, plan view, drawing.

14 *Polycladolithus?* sp.
Plan view.

15 *Isthmolithus unipons* Bramlette and Sullivan, n. sp.
Holotype, no. 564383, plan view.

16 *Isthmolithus unipons* Bramlette and Sullivan, n. sp.
a–b, side views of specimens from Lodo 43.

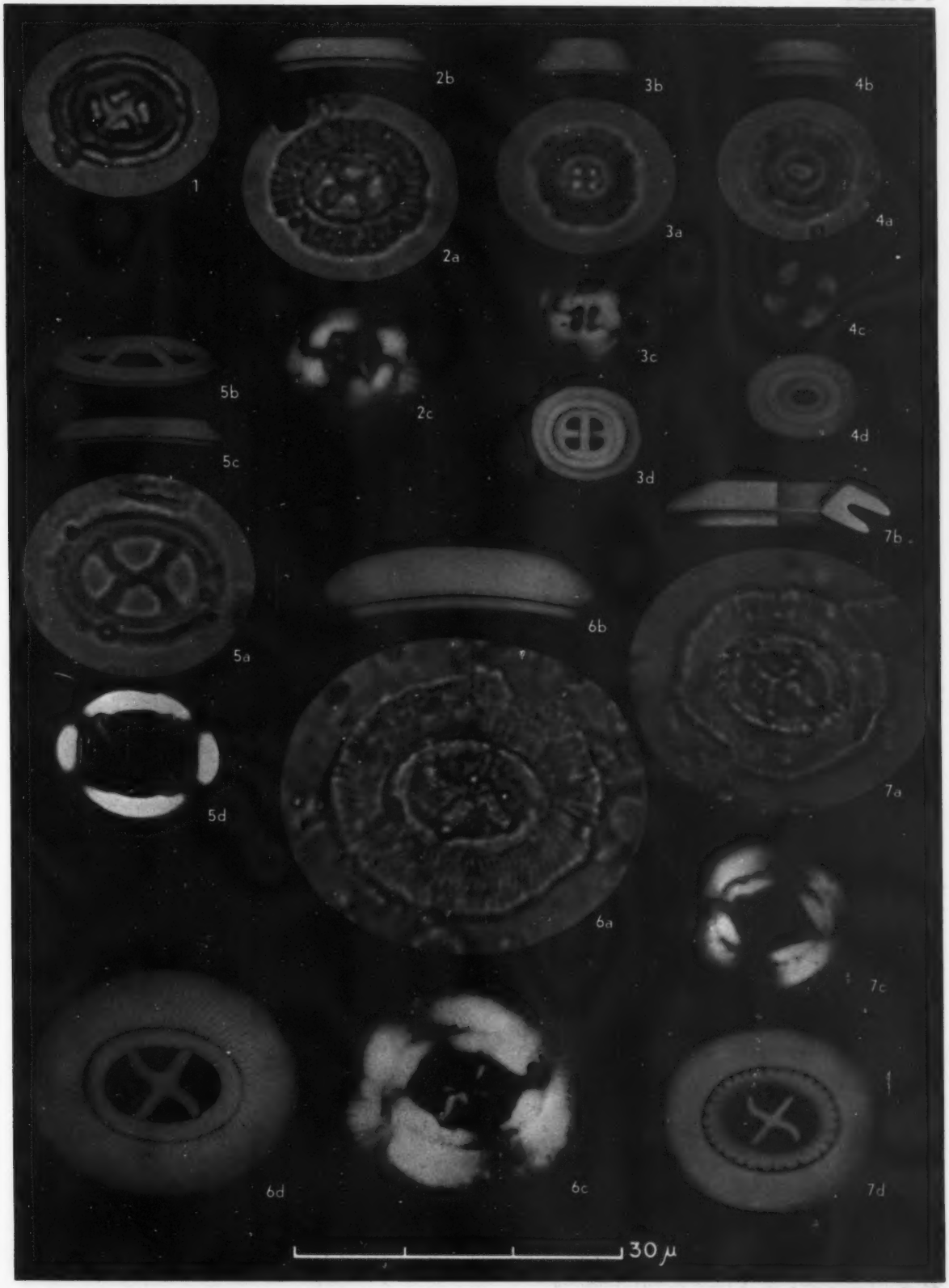
17 *Rhomboaster cuspis* Bramlette and Sullivan, n. sp.
Paratype no. 564388, oblique view.

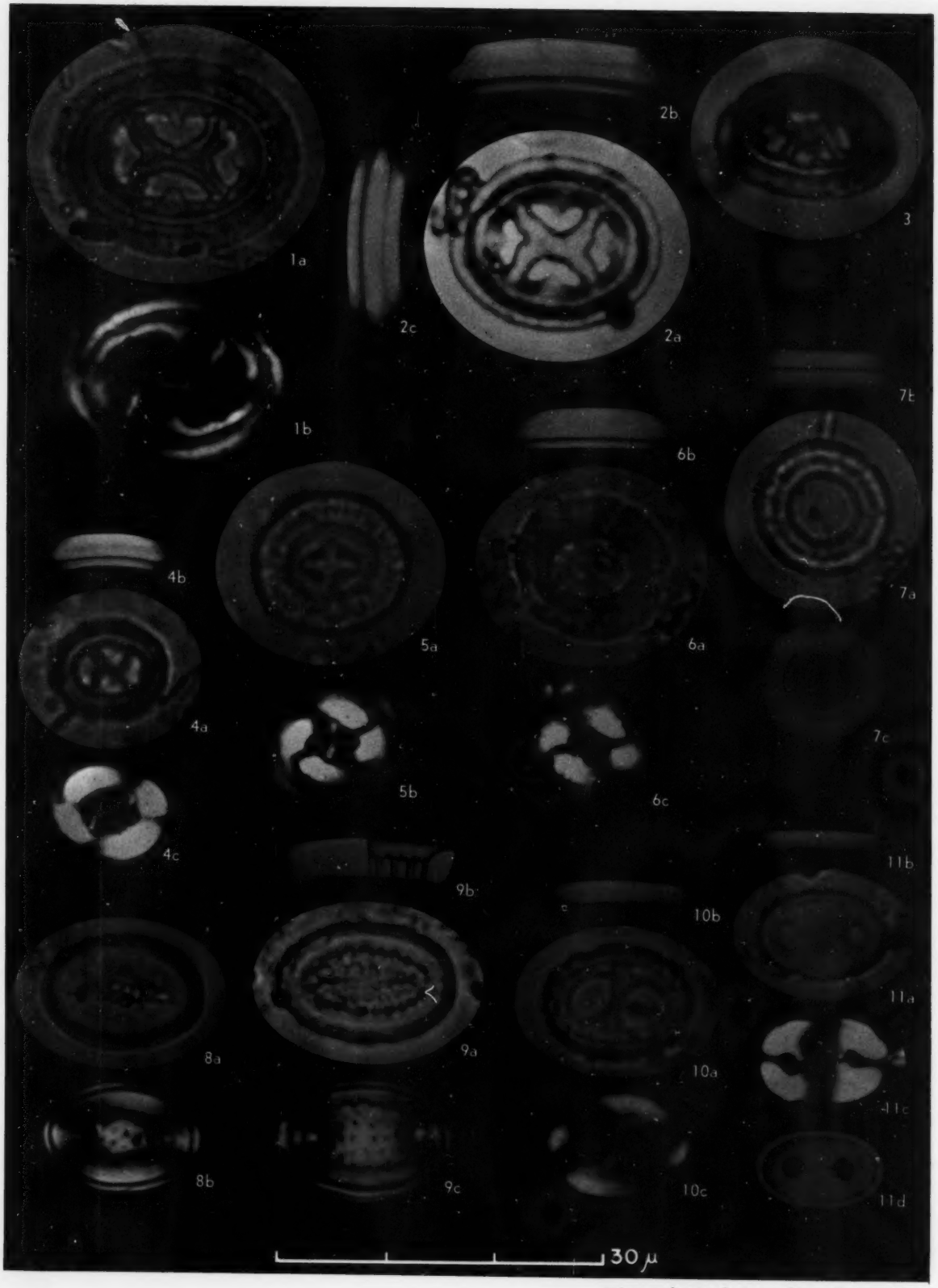
18 *Rhomboaster cuspis* Bramlette and Sullivan, n. sp.
Paratype no. 564387, oblique view.

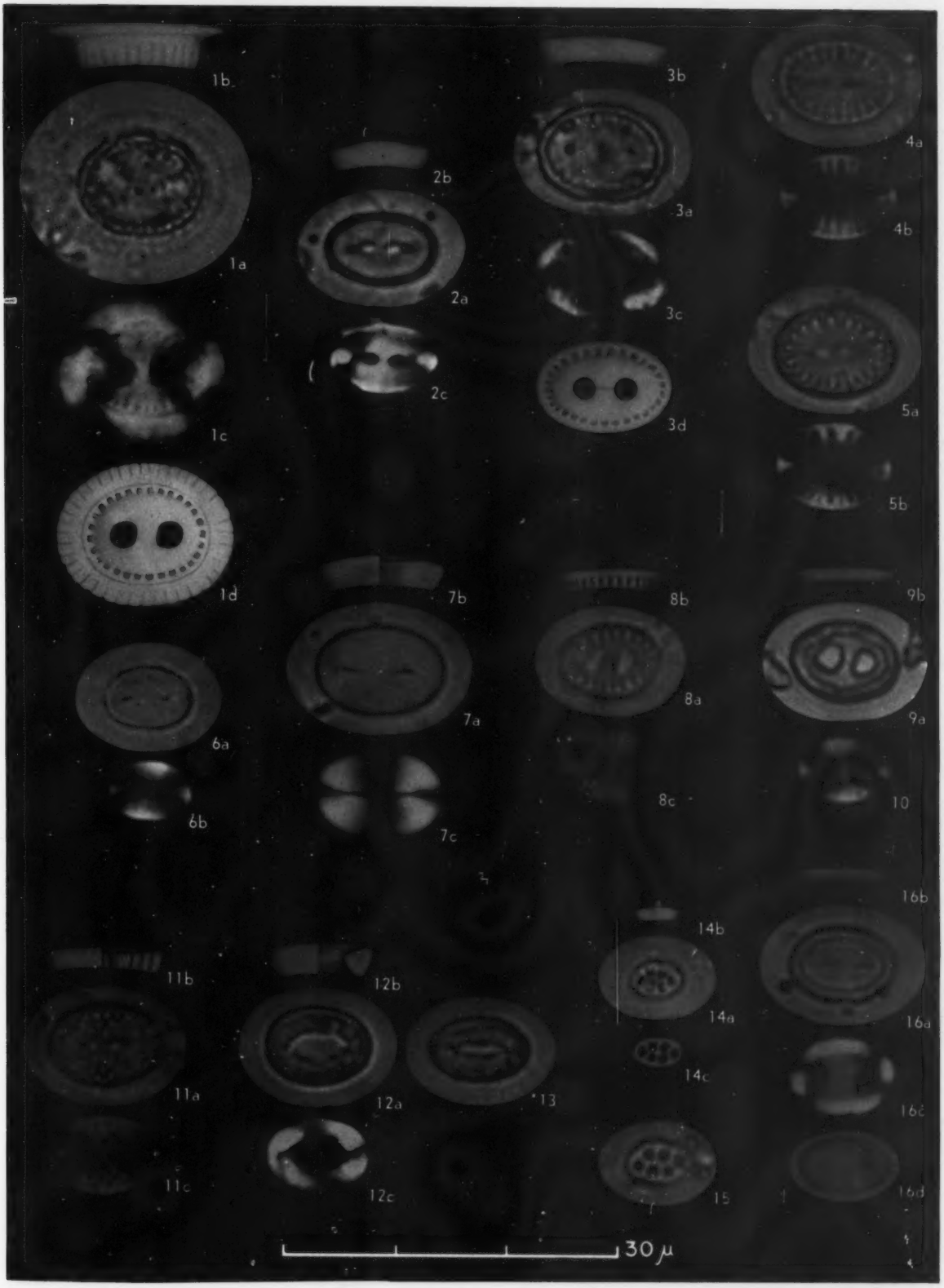
19 *Rhomboaster cuspis* Bramlette and Sullivan, n. sp.
Holotype, no. 564386: a, plan view with 3 edges of lower side showing through as the lighter ones; b, side view, drawing; c, plan view, drawing.

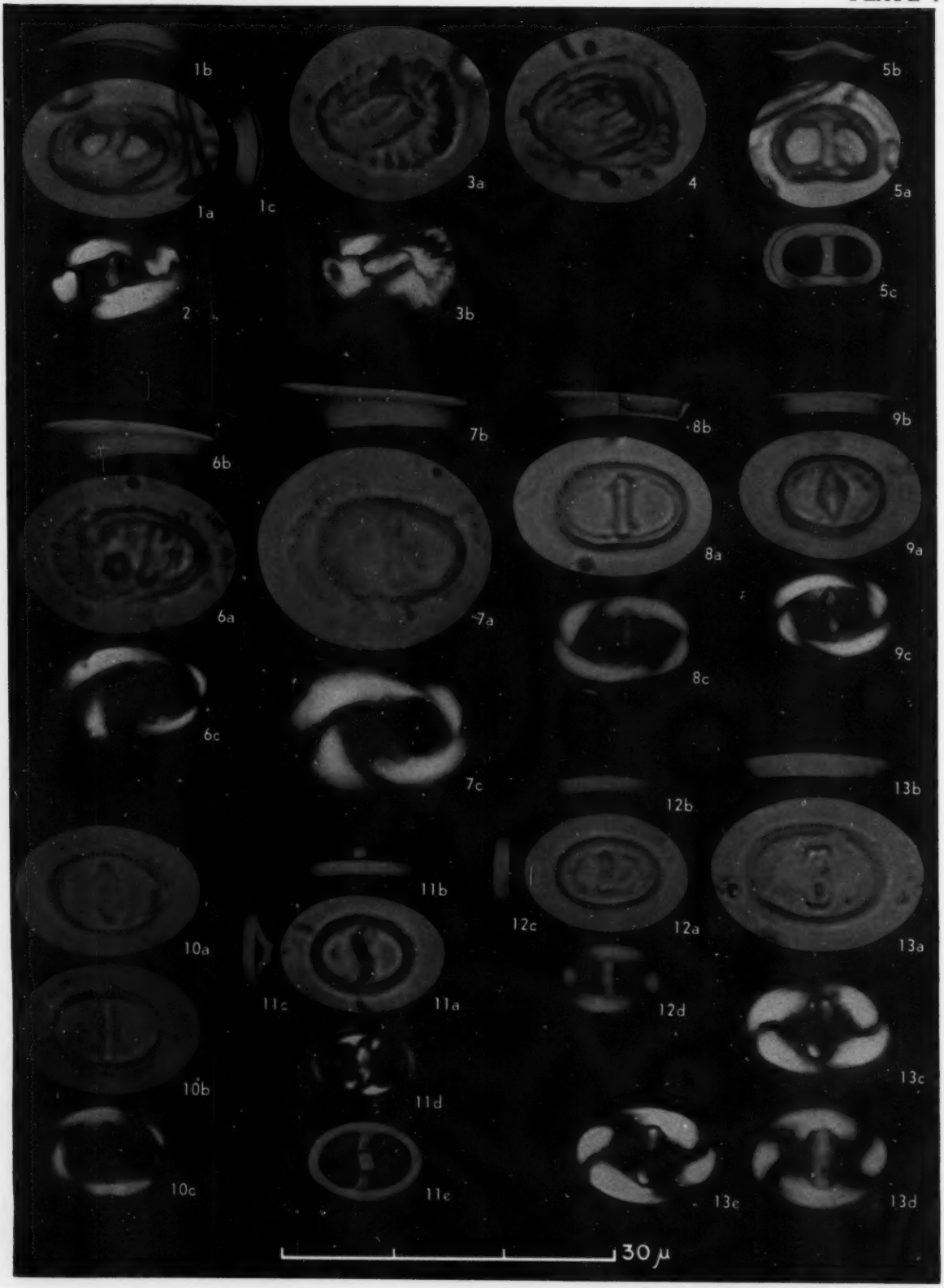
*Measured clockwise from either plane of crossed nicols.

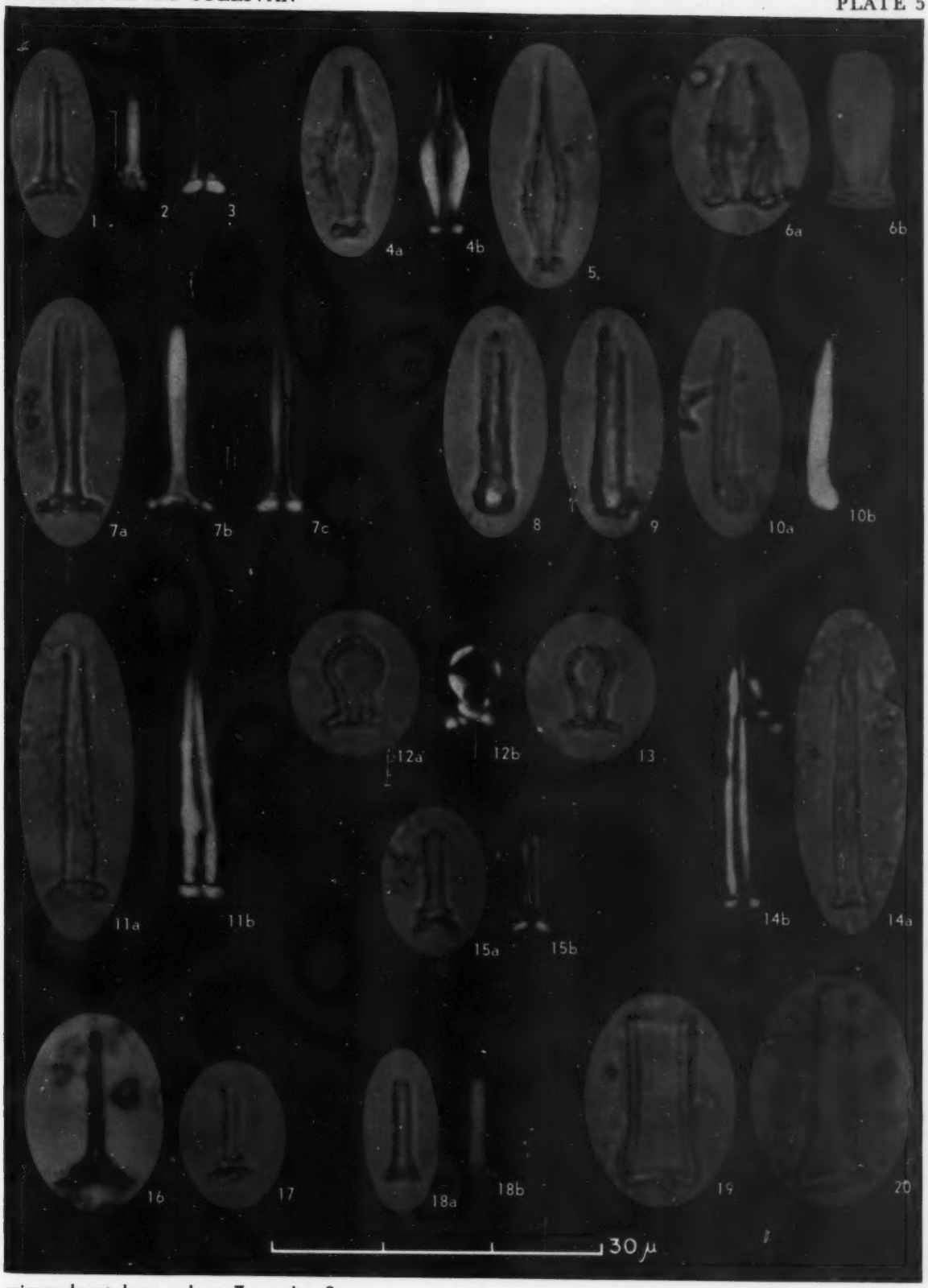
*Measured clockwise from either plane of crossed nicols.

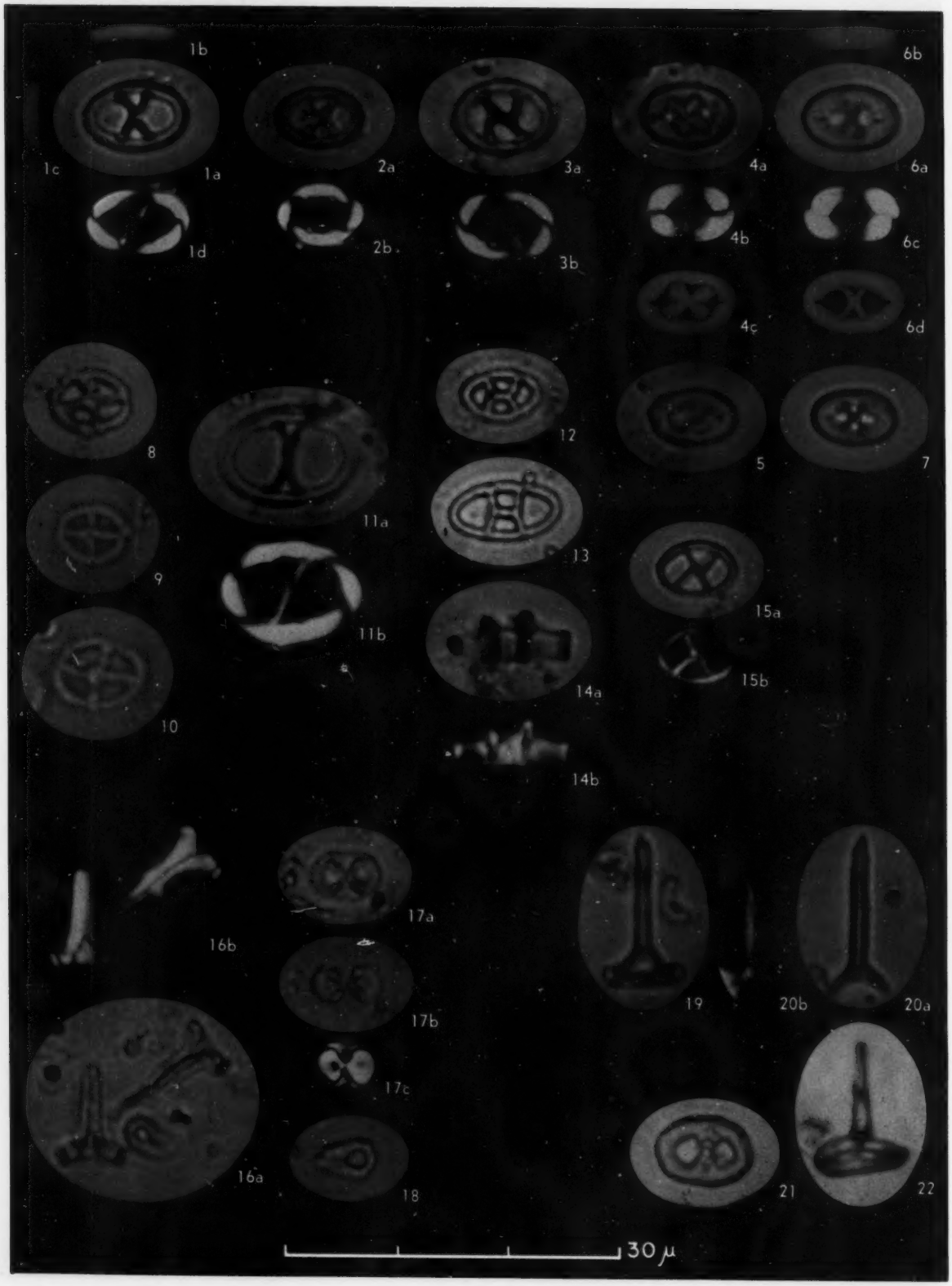

1
2b
2a
2c
3b
3a
3c
3d
4b
4a
4c
4d
5b
5c
5a
5d
7b
6b
7a
6a
7c
6d
6c
7d
30 μ

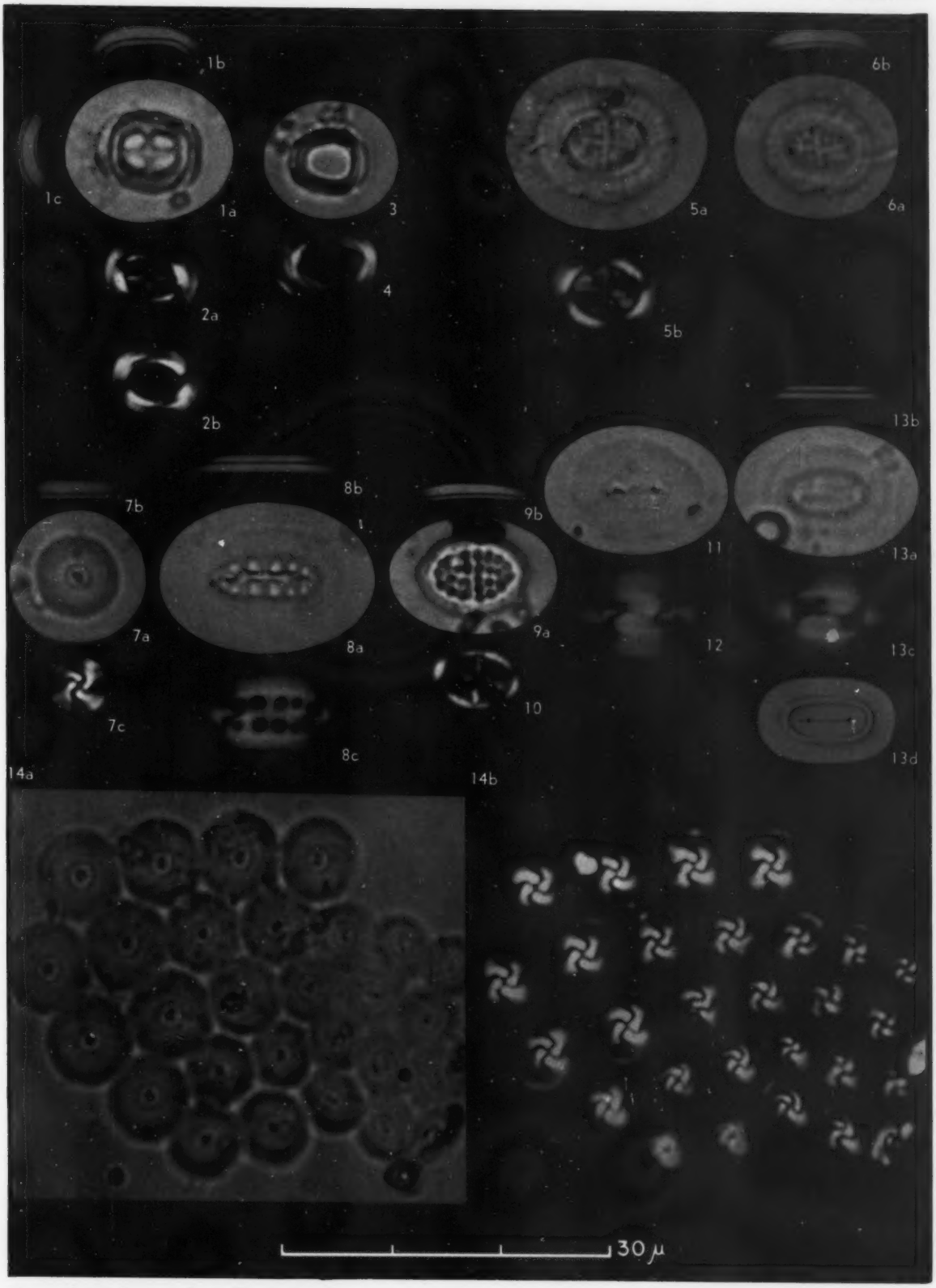

1a
1b
2a
2b
2c
3
4a
4b
4c
5a
5b
6a
6b
6c
7a
7b
7c
8a
8b
9a
9b
9c
10a
10b
10c
11a
11b
11c
11d
30 μ


1b
1a
1c
1d
2b
2a
2c
3b
3a
3c
3d
4a
4b
5a
5b
6a
6b
7b
7a
7c
8b
8a
8c
9b
9a
10
11b
11a
11c
12b
12a
12c
13
14b
14a
14c
15
16b
16a
16c
16d
30 μ


1b
1a
1c
3a
4
5b
5a
2
3b
5c
7b
8b
9b
6b
8a
9a
6a
7a
9c
8c
6c
7c
12b
13b
11b
12c
12a
13a
10a
11c
11a
12d
10b
11d
13c
10c
11e
13e
13d
30 μ

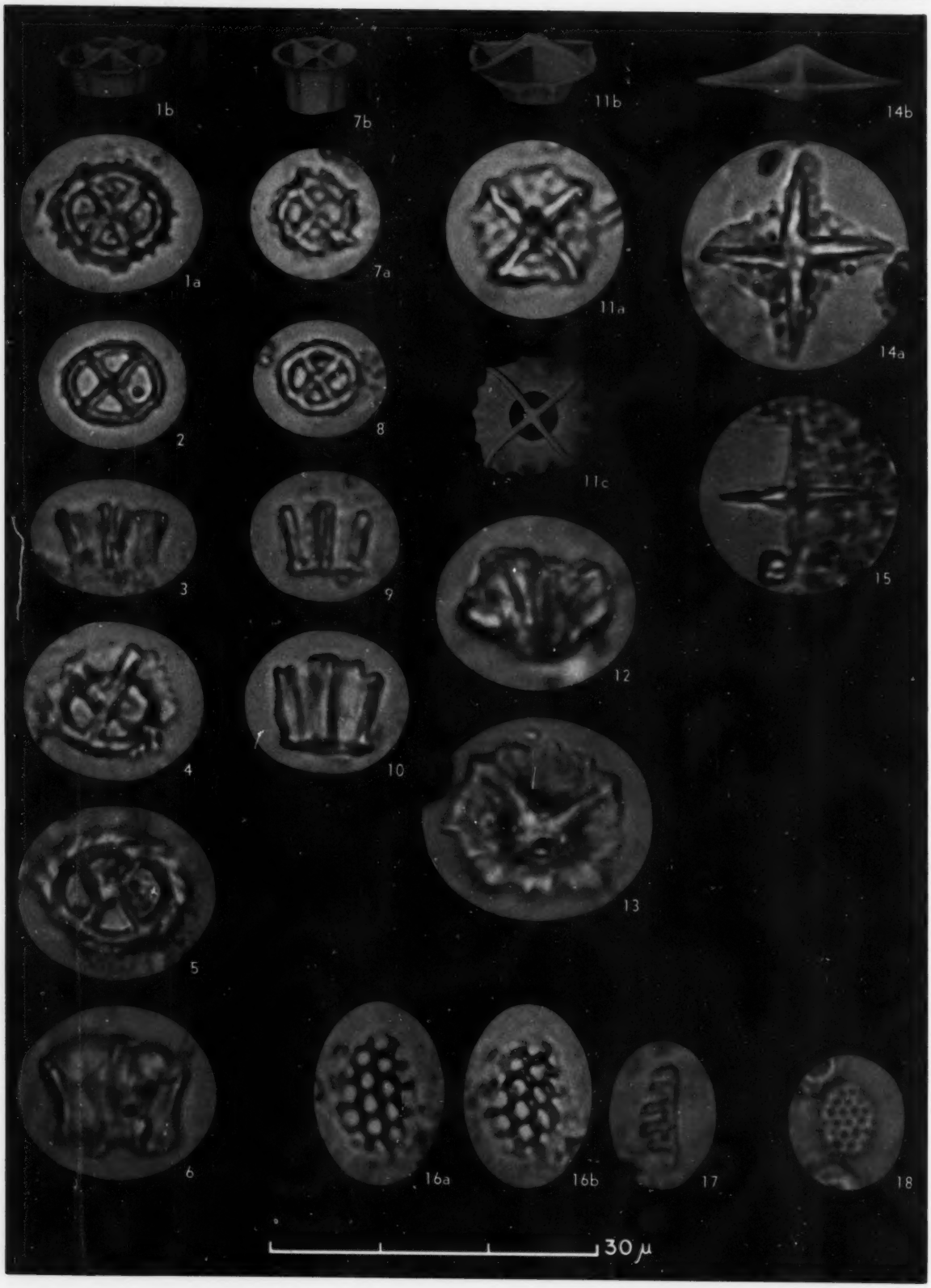

1
2
3
4a
4b
5
6a
6b
7a
7b
7c
8
9
10a
10b
11a
11b
12a
12b
13
14b
14a
15a
15b
16
17
18a
18b
19
20
30 μ


1b
1c
1a
1d
2a
2b
3a
3b
6b
4a
6a
4b
6c
4c
6d
8
12
5
7
11a
13
9
15a
11b
14a
15b
10
14b
16b
17a
17b
17c
19
20b
20a
16a
18
21
22
30 μ

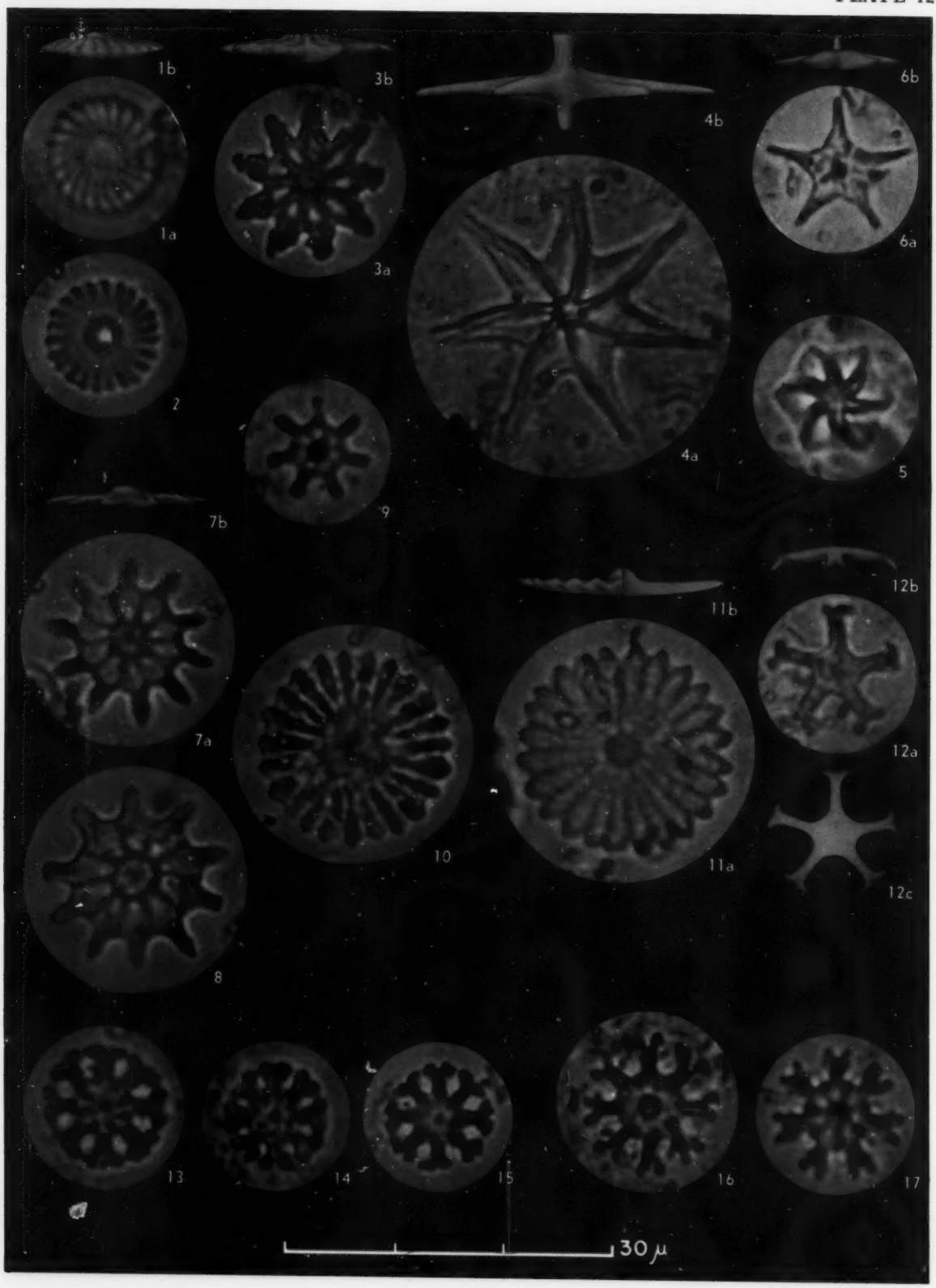

1b
1c
1a
3
6b
5a
6a
4
2a
5b
2b
13b
8b
7b
9b
11
13a
1
7a
8a
9a
12
13c
7c
10
8c
13d
14a
14b
30 μ

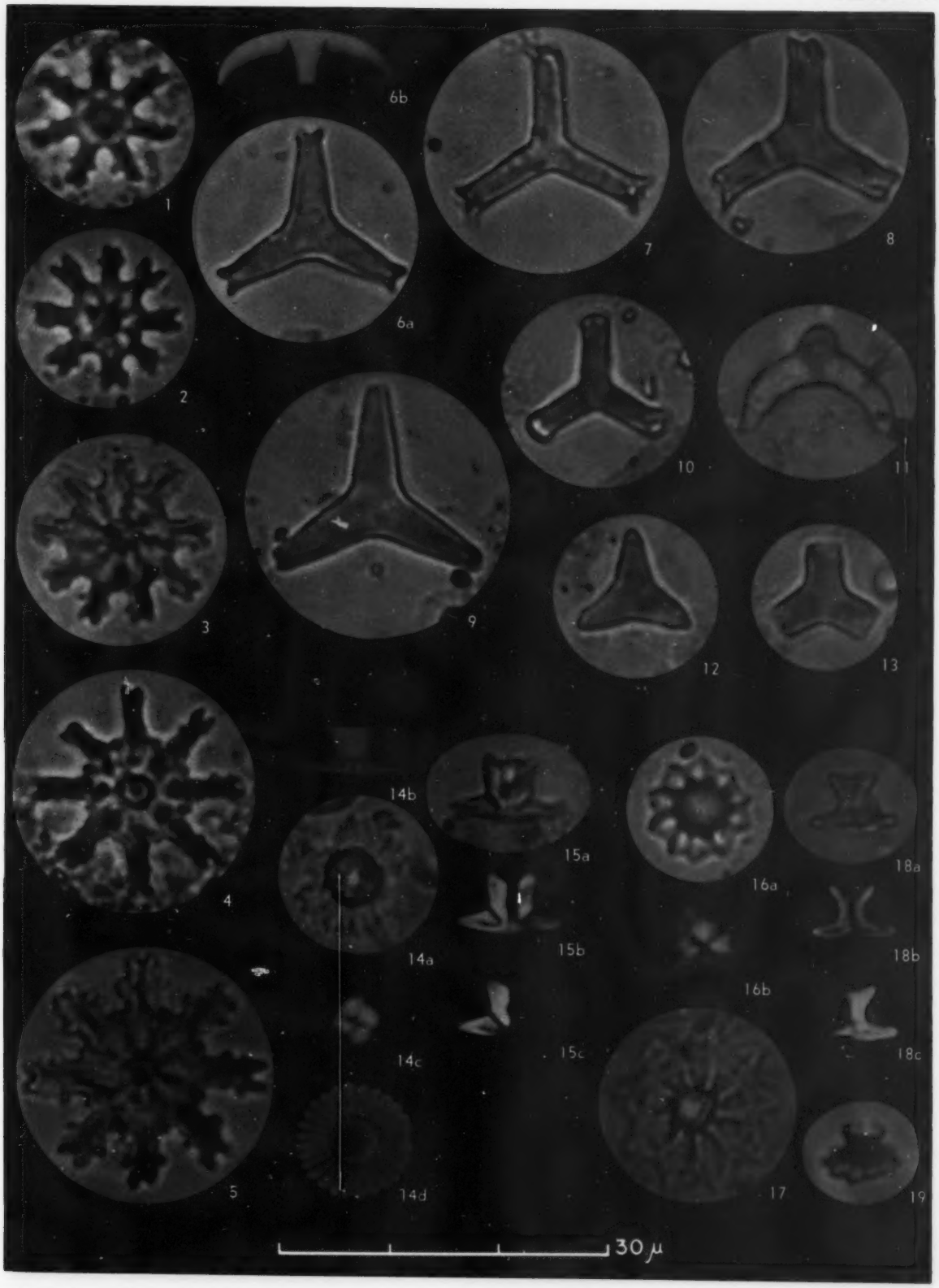
1b
2
3
1a
4
5
6b
7
6a
8a
9
10
11
14b
12a
13b
8b
14a
13a
15
14c
12b
30 μ

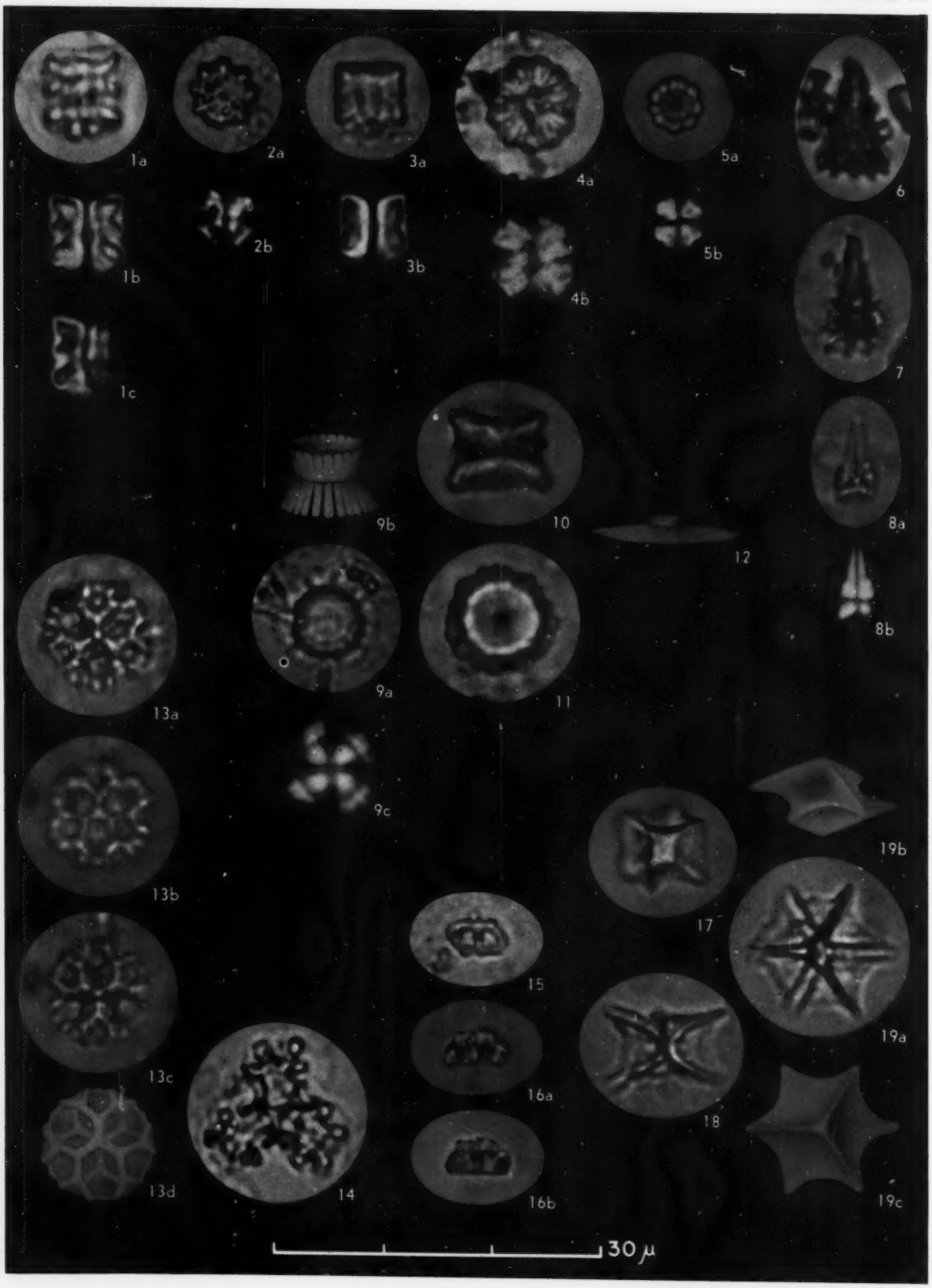
1b
1a
1c
2a
2b
3a
3b
4
5b
5a
5c
6
8a
8b
9a
9b
7a
7b
10a
10b
11
30 μ


1b
7b
11b
14b
1a
7a
11a
14a
2
8
11c
15
3
9
12
4
10
13
5
6
16a
16b
17
18
30 μ

1b
1a
2
3
4b
4a
5b
5a
6
7
9
8
10
14b
11
17
14a
12
16b
18b
13
15
16a
18a
30 μ


1b
3b
4b
6b
1a
3a
6a
2
4a
5
9
7b
12b
11b
7a
12a
10
11a
12c
8
13
14
15
16
17
30 μ


1
2
3
4
5
6a
6b
7
8
9
10
11
12
13
14a
14b
14c
14d
15a
15b
15c
16a
16b
17
18a
18b
18c
19
30 μ


1a
2a
3a
4a
5a
6
1b
2b
3b
4b
5b
7
1c
9b
10
12
8a
8b
13a
9a
11
9c
19b
13b
17
15
19a
13c
16a
18
13d
14
16b
19c
30 μ

ABSTRACT

The status of the genera Ammodiscus *Reuss, 1862, and* Involutina *Terquem, 1862, is discussed on the basis of their revision by Bornemann, 1874, and Loeblich and Tappan, 1954.* Ammodiscus *Reuss is retained for agglutinated planispiral evolute species, similar to the type species* Ammodiscus infimus *Bornemann, 1874 (not Strickland, 1846)* = Ammodiscus siliceus *(Terquem), 1862.* Involutina *Terquem is restricted to those planispiral calcareous species, with lateral umbilical filling, similar to the type species* Involutina jonesi *Terquem and Piette (1862)* = Involutina liasina *(Jones), 1853.*

The status of the foraminiferal genera Ammodiscus Reuss, and Involutina Terquem

ALFRED R. LOEBLICH, JR. AND HELEN TAPPAN
California Research Corporation
La Habra, California
and
University of California
Los Angeles, California

INTRODUCTION

Ammodiscus Reuss and *Involutina* Terquem were described in 1862, and included planispirally coiled foraminifera. Both were described without citation of type species.

Although nearly all micropaleontologists recognize the form so abundantly represented in foraminiferal literature as *Ammodiscus*, this genus has been the subject of considerable taxonomic confusion to which the present writers inadvertantly added some half dozen years ago. The taxonomic status of *Involutina* is far less complex, although as a genus it has been generally misunderstood.

It is hoped that the present article will clarify the status of these two dissimilar genera, which have been the subjects of so much confusion.

STATUS OF INVOLUTINA TERQUEM, 1862

Terquem (1862) originally included calcareous and agglutinated species in *Involutina*, both *Involutina silicea* Terquem and *Involutina jonesi* Terquem and Piette appearing in the original publication.

Cushman (1928) designated *Involutina silicea* as type of the genus, and was generally followed in this by other writers. Loeblich and Tappan (1954) restudied this species, and as it was an agglutinated form regarded *Involutina* as equivalent to the genus previously considered as *Ammodiscus* by the majority of workers.

However, as was noted by Ellis and Messina (Catalogue of Foraminifera), the earlier emendation of *Involutina* by Bornemann (1874) had restricted *Involutina* to the calcareous species. Bornemann had reallocated generically seven of the eight species that had been referred to *Involutina* by Terquem (1862, 1863, 1866) and left only *Involutina jonesi* Terquem and Piette (= *Nummulites liasinus* R. Jones) in this genus. *Involutina jonesi* Terquem and Piette, thus became the type species of *Involutina* by elimination. Bornemann also definitely stated (p. 711) that he restricted the previously inclusive generic name *Involutina* to *Involutina jonesi*, because it was the only one (of the original species) remaining, when *Involutina silicea* was transferred to *Ammodiscus*. He later (p. 713) regarded *I. jonesi* as a synonym of *Nummulites liasinus* Jones. *Nummulites liasinus* Jones was not among the species included in *Involutina* by Terquem, however, so the type species must be cited as *Involutina jonesi* Terquem and Piette, even if this is regarded as a synonym of Jones' species. The status of *Involutina*, with type species *I. jonesi* was clarified by Wicher (1944, p. 348; 1952, p. 270), who correctly showed that it referred to a calcareous form and not to the group therein placed by Cushman, in citing *I. silicea* as type species. Wicher's articles had not been seen by the present writers at the time of publication of their discussion of *Ammodiscus* and *Involutina*. Wicher (1944, p. 349) noted that Bornemann had already fixed the type of *Involutina* as *I. jonesi*, and that consideration of *Ammodiscus siliceus* as the type was impossible. In 1952, Wicher redescribed *Involutina* with excellent illustrations of its structure and a discussion of its relationships.

Involutina thus is a calcareous form, related to *Cornuspira* and *Trocholina*, and has no relationship to the agglutinated Ammodiscidae or to secreted siliceous forms ("Silicinidae"). The type species is *Involutina jonesi* Terquem and Piette, 1862 (= *I. liasina* (Jones), 1853).

STATUS OF AMMODISCUS REUSS, 1862

The genus *Ammodiscus* Reuss, 1862, was described without designation of a type species and no species were named in the original reference. In 1898, Schellwien designated *Operculina incerta* d'Orbigny, 1839, as the type species of the genus and this species was cited as type in most of the subsequent publications on foraminifera. However, this was not the earliest species placed in the genus, and an emendation of *Ammodiscus* by Loeblich and Tappan (1954) stated that this was an invalid designation. Furthermore, their restudy of the types of *Operculina incerta* showed it to be an imperforate calcareous species, belonging to the genus *Cornuspira* Schultze, 1854. Thus, this species did not even fit the original generic diagnosis given by Reuss, nor the later emendation of the genus without type citation by Rhumbler (1895).

Loeblich and Tappan (1954, p. 307) stated that the first foraminiferal species cited in connection with *Ammodiscus* was *Ammodiscus infimus* (Strickland) Bornemann, 1874, p. 725 (= *Orbis infimus* Strickland, 1846). They state "As this is the first valid reference citing a species of *Ammodiscus* it automatically becomes the type species of *Ammodiscus*". They, therefore, cite (p. 306) as type species of *Ammodiscus* Reuss, 1862, emended — "*Orbis infimus* Strickland, 1846. Fixed by subsequent monotypy: Bornemann (1874, p. 725)". The latter statement was in error, however, as shown below, for Bornemann included more than one species in *Ammodiscus* in 1874. Loeblich and Tappan stated that *Ammodiscus* Reuss, 1862, thus would have to be suppressed as a junior synonym of *Spirillina* Ehrenberg, 1843, for *Orbis infimus* Strickland had already been shown to be a hyaline calcareous species (Barnard, 1952).

Ellis and Messina (1957), in discussion of the emendation of *Ammodiscus* by Loeblich and Tappan, noted that the species *Orbis infimus* Strickland did not become type of *Ammodiscus* by subsequent monotypy, for they stated that Bornemann had referred two species to *Ammodiscus*, i.e., *Orbis infimus* Strickland, 1846, and *Involutina aspera* Terquem, 1864. Ellis and Messina added that "Neither species was designated as the type of *Ammodiscus*".

Thus, the designation of *Orbis infimus* as type of *Ammodiscus* has validity only on the basis of such designation by Loeblich and Tappan, 1954, not by subsequent monotypy.

Previous revisions and discussions of *Ammodiscus* by Bornemann (1874, p. 724), Rhumbler (1895, p. 84), and Wicher (1944, p. 349; 1952, p. 270), which had been overlooked by later workers had restricted *Ammodiscus* to include only arenaceous species. No statement of actual type designation had been made by these authors, however, and according to the Rules of Zoological Nomenclature (Art. 30 IIg), if the original author did not select a type "any subsequent author may select the type, and such designation is not subject to change. (Type by subsequent designation.) The meaning of the expression 'select the type' is to be rigidly construed".

The article by Loeblich and Tappan (1954) had considered (erroneously) the type of *Ammodiscus* to be fixed by subsequent monotypy, and was not stated to be a designation of a type species. Therefore, the status of *Orbis infimus* as type of *Ammodiscus* was questioned by Ellis and Messina (1957, discussion of *Ammodiscus*) stating that "It is not clear, on the basis of the revised International Rules of Zoological Nomenclature, whether or not it is possible to designate a type species unintentionally". They add that "an opinion expressed in the Bulletin of Zoological Nomenclature (1950, vol. 4, pp. 181–182, Concl. 72) states that 'an effective selection of a type species may consist of a mere statement that the author accepts for whatever reason ..... that species as type of a specified genus' (Follett, 1955, Unofficial interpretation of the International Rules of Zoological Nomenclature as emended, etc., p. 44)".

Loeblich and Tappan further regarded the generic name *Involutina* (with type species *I. silicea* Terquem) as available for the agglutinated forms previously referred to *Ammodiscus*.

This solution for the genera *Ammodiscus* and *Involutina* was not accepted by many workers. Pokorny (1958, p. 174) suggested that possibly a petition to the ICZN would be necessary to clarify the status of the genotype, but recognized *Ammodiscus* as an agglutinated form, and also recognized the family and subfamily names based on it, i. e., Ammodiscidae and Ammodiscinae. Voloshinova, Dain and Reitlinger (1959, p. 177–181) recognized *Ammodiscus* (with *Operculina incerta* d'Orbigny as type species), and the subfamily Ammodiscinae, family Ammodiscidae, superfamily Ammodiscidea, and order Ammodiscida, commenting that they could not accept the consideration of *Ammodiscus* as a calcareous genus, inasmuch as earlier revisions (including that of Rhumbler, 1895, who erected the family Ammodiscidae) had restricted it to include only arenaceous species. Nevertheless, *Operculina incerta* cannot be considered as type for an agglutinated *Ammodiscus* because (1) it was not included among the first species placed in the genus, and (2) it is a calcareous, imperforate species, belonging to *Cornuspira*.

The first revision of *Ammodiscus* was included in a revision of the genus *Involutina* (Bornemann, 1874). Bornemann divided the eight species which had been earlier referred to *Involutina* Terquem into four groups, based on wall character, and presence or absence of septation. He restricted *Involutina* to include only *Involutina jonesi* Terquem and Piette, 1862, and described the new genera *Silicina* for the species *Involutina polymorpha* Terquem, 1863, and *I. limitata* Terquem, 1863, and the genus *Problematina* for the species *I. deslongchampsi* Terquem, 1863, *I. petraea* Terquem, 1866, and *I. nodosa* Terquem, 1866. This left two of Terquem's species which had agglutinated walls, according to Bornemann,

I. silicea Terquem, 1862, and *I. aspera* Terquem, 1863. Later in the publication Bornemann (p. 725, 729) described the species *Ammodiscus infimus* (Strickland) (including *Involutina silicea* as a synonym) and *Ammodiscus asper* Terquem, these being the two species regarded as available for designation as type by Ellis and Messina (1957). Actually the species *Involutina silicea* Terquem was the first to be cited by Bornemann in connection with *Ammodiscus*. His comments on this species could be construed as an intended type designation, although not definitely so stated. Bornemann (1874, p. 711) stated that of the species previously included in *Involutina*, only the group of *Involutina silicea* could be assigned to a previously known genus—the genus *Ammodiscus* Reuss. *Involutina* was restricted to the calcareous species of the monotypic "group" of *Involutina jonesi*, as it was the only species remaining of those originally included in *Involutina* when *Involutina silicea* is transferred ot *Ammodiscus*. He therefore regarded *I. jonesi* as typical of *Involutina* and *I. silicea* as typical of *Ammodiscus*.

The confusion which has since arisen is due to the fact that Bornemann mistakenly assumed that *I. silicea* Terquem was a synonym of *Orbis infimus* Strickland, and therefore included it in the synonymy of *Ammodiscus infimus* (Strickland) (1874, p. 725). However, his description of *Ammodiscus infimus* shows clearly that he was in fact describing Terquem's species, and not that of Strickland. He states that he had obtained some of the original material of Terquem, through Herr v. Roehl, and additional material from Metz. He also had material of *Operculina liasina* Brauns (which he also regarded as a junior synonym of *A. infimus*). Bornemann stated (p. 727) that *A. infimus* was not identical with *Trochammina incerta* (d'Orbigny), however, as had been stated by Parker and Jones (Carpenter, 1862, p. 141). *Operculina incerta* was later erroneously designated as type of *Ammodiscus* by Schellwien (1898) and Cushman (1910), although not among the originally included species and was later proven to belong to *Cornuspira*. The numerous localities from which Bornemann obtained material were all from France and Germany, but the types of Strickland's species were from England. Bornemann stated (p. 728) that he referred his specimens to Strickland's species even though their siliceous character was not observed by Strickland, as the over-all appearance, size, etc., compared perfectly with Terquem's species. As Strickland's species has been proven to be a hyaline calcareous form (and to belong to *Spirillina*), it is obvious that Bornemann's description of *A. infimus* was based on his own material and that of Terquem's species.

The following Rules of Zoological Nomenclature and additions apply to the present case (Anonymous, 1926, p. 83, 84; Hemming, 1953) "Article 30 II. Cases in which the generic type is accepted not solely upon basis of the original publication. (g) If an author, in publishing a genus with more than one valid species, fails to designate or indicate its type, any subsequent author may select the type, and such designation is not subject to change. (Type by subsequent designation.) The meaning of the expression 'select the type' is to be rigidly construed. Mention of a species as an illustration or example of a genus does not constitute a selection of a type". Article 30, paragraph 128 (Hemming, 1953, p. 69) states "(1) where an author establishes a nominal genus for which he designates as the type species a previously established nominal species and at the same time indicates that he is applying the specific name not to the taxon represented by the nominal species so named but to some other taxon erroneously identified therewith by some later author, the species to be accepted as the type species shall be, not the nominal species cited by the author of the generic name but the species which that author clearly indicated was that to which he was referring when he designated the type species of the genus concerned. (2) The foregoing rule shall apply also ... to the case where the author of a new generic name, without designating a type species for the nominal genus so established, places in it a species under a name which he clearly indicates that he is using in a different sense from that of its original author, and the species so indicated is the first of the included species to be selected as the type species under Rule (g) in Article 30. (3) In a case such as that specified in (1) or (2) above, the type species of the new genus is to be treated as having been given a new binomen composed of the cited generic name and of a specific name consisting of the same word as that borne by the species under which the type species was erroneously cited by the author of the new generic name".

In view of the above discussion and Rules, the type species of *Ammodiscus* is *Ammodiscus infimus* Bornemann, 1874 (not *Orbis infimus* Strickland, 1846) = *Involutina silicea* Terquem, 1862; fixed by subsequent designation by Loeblich and Tappan, 1954, p. 306, emended herein 1961. This designation is substantiated as follows: (1) Bornemann (1874, p. 711) stated that the group of *Involutina silicea* was to be referred to *Ammodiscus*, and definitely mentioned the removal of this species to *Ammodiscus* (page preference). (2) Bornemann's description of the genus *Ammodiscus* was based on original material of Terquem's *Involutina silicea*, and not on material of any other previously described species. (3) The only other species placed by Bornemann in *Ammodiscus* is *Involutina aspera* Terquem, 1863. The description of this species was quoted from Terquem, and Bornemann only provisionally recognized it, stating (as was noted by Wicher, 1944, pp. 349–350) that possibly it might also be a synonym of *A. infimus* (as was understood by Bornemann, not that of Strickland). Wicher also regarded *I. aspera* as synonymous with *Ammodiscus infimus*. Thus according to Bornemann only one species regarded as completely valid was referred to *Ammodiscus* (= virtual monotypy). (4) The citation of *Orbis infimus* Strickland as type species, by Loeblich and Tappan (1954) was based on the placement of *O. infimus* in *Ammodiscus* by Bornemann and the erroneous assumption that Bornemann had fixed the type by

subsequent monotypy. Nevertheless, although not intended as a type fixation itself, but merely as a citation of an earlier type designation, the acceptance of this species as type by Loeblich and Tappan fixed it without possibility of change. (5) The citation of Bornemann's article as fixing the type, although erroneous, thus hinges the type validity upon that publication. Bornemann had erroneously assumed *Orbis infimus* to be a prior synonym of *Involutina silicea* and his description of *Ammodiscus infimus* (Strickland) leaves no doubt that it was based on material erroneously identified with that species, but correctly belonging to *Involutina silicea* Terquem (misidentification of species selected as type). (6) The specific designation of the type species, according to paragraph 212 (cited above), should therefore be *Ammodiscus infimus* Bornemann, 1874. As this is a junior synonym of *Involutina silicea* Terquem, 1862, the species may be referred to as *Ammodiscus siliceus* (Terquem).

REFERENCES

ANONYMOUS
1926 – *International Rules of Zoological Nomenclature.* Biol. Soc. Washington, Proc., vol. 39, pp. 75–104.

BARNARD, T.
1952 – *Notes on Spirillina infima (Strickland) Foraminifera.* Ann. Mag. Nat. Hist., ser. 12, vol. 5, pp. 905–909.

BORNEMANN, L. G.
1874 – *Über die Foraminiferengattung Involutina.* Deutsche Geol. Gesell., Zeitschr., vol. 26, pp. 702–749, pls. 18–19.

CARPENTER, W. B.
1862 – *Introduction to the Study of the Foraminifera.* Ray Soc., London, pp. 1–319, pls. 1–22.

CUSHMAN, J. A.
1910 – *Monograph of the Foraminifera of the North Pacific Ocean; Pt. 1 Astrorhizidae and Lituolidae.* U. S. Nat. Mus., Bull. 71, pp. 1–134, text-figs. 1–203.
1928 – *Foraminifera, their classification and economic* use. Cushman Lab. Foram. Res., Spec. Publ., no. 1, pp. 1–401.

ELLIS, B. F. and MESSINA, A. R.
1957 – *Catalogue of Foraminifera, supplement for 1951.* Amer. Mus. Nat. Hist., Spec. Publ.

FOLLETT, W. I.
1955 – *Unofficial Interpretation of the International Rules of Zoological Nomenclature.* Distributed by the Society of Systematic Zoology (not published).

HEMMING, F.
1953 – *Copenhagen Decisions on Zoological Nomenclature. Additions to, and Modifications of, the Règles internationales de la Nomenclature Zoologique.* London, 135 pp.

LOEBLICH, A. R. JR., and TAPPAN, H.
1954 – *Emendation of the foraminiferal genera Ammodiscus Reuss, 1862, and Involutina Terquem, 1862.* Washington Acad. Sci., Jour., vol. 44, no. 11, pp. 306–310, figs. 1–2.

POKORNÝ, V. J.
1958 – *Grundzüge der Zoologischen mikropaläontologie.* Berlin; vol. 1, 582 pp.

REUSS, A. E.
1862 – *Entwurf einer systematischen Zusammenstellung der Foraminiferen.* Akad. Wiss. Wien, Math.-Nat. Kl., Sitzb., vol. 44 (1961), no. 1, pp. 355–396.

RHUMBLER, L.
1895 – *Entwurf eines natürlichen Systems der Thalamophoren.* K. Ges. Wiss. Göttingen, Math.-Physik. Kl., Nachr., no. 1, pp. 51–98.

SCHELLWIEN, E.
1898 – *Die Fauna des karnischen Fusulinenkalks; Teil II.* Palaeontographica, vol. 44 (1897–1898), nos. 5–6, pp. 237–282, pls. 17–24.

STRICKLAND, H. E.
1846 – *On two species of microscopic shells found in the Lias.* Geol. Soc. London, Quart. Jour., vol. 2, pp. 30–31.

TERQUEM, O.
1862 – *Recherches sur les foraminifères de l'Etage Moyen et de l'Etage Inférieur du Lias, 2e Mémoire.* Acad. Imp. Metz, Mém., ann. 42, (ser. 2, ann. 9) 1860–1861, pp. 415–466, pls. 5–6.
1863 – *Troisième Mémoire sur les Foraminifères du Lias des Départements de la Moselle, de la Côte-d'Or, du Rhône, de la Vienne et du Calvados.* Acad. Imp. Metz, Mém., vol. 44, pp. 361–438, pls. 7–10.
1866 – *Cinquième Mémoire sur les Foraminifères du Lias des Départements de la Moselle, de la Côte-d'Or, et de l'Indre.* Metz: Lorette, pp. 313–454, pls. 15–18.
1866 – *Sixième Mémoire sur les Foraminifères du Lias des Départements de l'Indre et de la Moselle.* Metz: Lorette, pp. 459–532, pls. 19–22.

VOLOSHINOVA, H. A., DAÏN, L. G. and REITLINGER, E. A.
1959 – *Order Ammodiscida, in Osnovy Paleontologii.* Akad. Nauk. SSSR, Moscow, pp. 177–190.

WICHER, C. A.
1944 – *Mikropaläontologische Mitteilungen; 1.* Pal. Zeitschr., vol. 23, no. 3–4, pp. 344–353.
1952 – *Involutina, Trocholina und Vidalina – Fossilien des Riffbereichs.* Geol. Jahrb., vol. 66, pp. 257–284, 4 figs.

ABSTRACT

The morphology, possible relationships, and distribution of fossil pollen of the genus Aquilapollenites *are discussed, and the original generic description is emended. Seven new species are described.*

Pollen of the genus Aquilapollenites

JOHN W. FUNKHOUSER
Jersey Production Research Company
Tulsa, Oklahoma

Fossil pollen assignable to the genus *Aquilapollenites* Rouse (1957) constitute one of the more exotic groups of angiosperm pollen. In fact, there has been discussion as to whether they really are angiosperms. Some species are superficially similar to spores, and the winglike equatorial protrusions common to this group have led to the conjecture that they may be hitherto unknown gymnosperms.

Prolonged study of many specimens of a number of species, however, has given strong evidence that they are angiosperm pollen with colpate apertures of one form or another (text-figure 1). The fact that in the normal orientation of most species nothing more than the locus of the apertures can be seen has not aided in their interpretation. If enough specimens are seen, though, occasional ones show the apertures. Other species, for the most part represented by rare specimens, exhibit the apertures clearly.

Superficially, the most bizarre part of the morphologies of these grains is their equatorial and polar winglike protrusions. Those of the equator are particularly striking, sometimes being quite attenuated. In some species the polar and equatoral protrusions are about equal, making it difficult to tell them apart.

Representatives of this genus may be either isopolar or heteropolar. In the heteropolar members one pole is greatly reduced so that it is only a minor convexity, or in extreme cases a concavity. It is assumed that this is the proximal pole. In these heteropolar forms the equatorial protrusions generally slant backward to a greater or lesser degree in the direction of the reduced pole. Ornamentation, though more or less lacking in a few species, is generally composed of spines, punctae, reticulae, striae, or a Bertillon pattern (this term is borrowed from the morphological terms used for trilobites; it means a pattern of raised lines simulating a fingerprint).

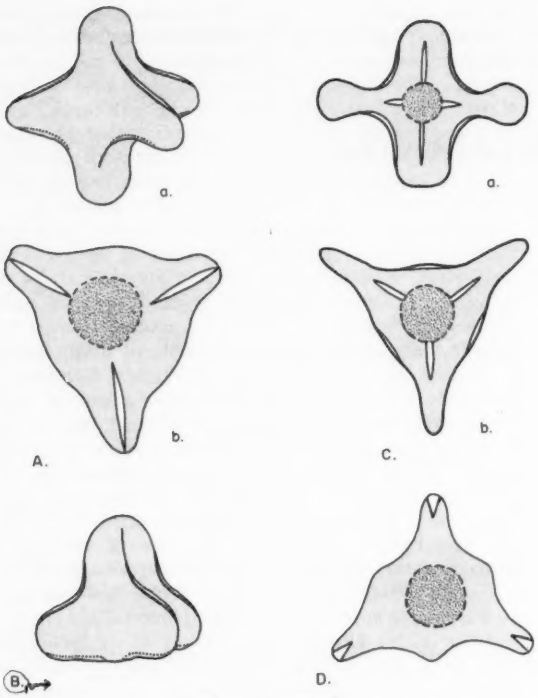
The closest modern counterparts that I have seen belong to the Santalaceae. The pollen of this family are both isopolar and heteropolar and have a wide variety of aperture arrangements. *Arjona pusilla*, for example, is superficially not unlike some *Aquilapollenites*.

Present evidence shows that *Aquilapollenites* pollen first appears in the Albian (Lytle formation, Colorado; personal communication from L. R. Wilson) and reaches its greatest diversity in the uppermost Cretaceous of western North America. It continues into at least the lower Eocene of the Rocky Mountain region. To my knowledge, there are no Cretaceous records of it outside North America. One species apparently referable to this genus was reported by Thomson and Pflug (1953) as *Periporopollenites pentangulus* in horizons from the Paleocene to the Oligocene of Germany. Krutzsch (1957) erected a new genus, *Pentapollenites*, and made Thomson and Pflug's *Periporopollenites pentangulus* its type species. It is impossible to tell for certain from Krutzsch's illustrations whether the specimens he refers to as *Pentapollenites pentangulus* are the same as Thomson and Pflug's or whether they are referable to *Aquilapollenites*. From the generic description that he gives for *Pentapollenites*, one would assume that he is dealing with something else. Another species that may possibly belong to this genus is illustrated in Pokrovskaya (1956, p. 213, fig. 27).

Dr. Rouse has kindly lent me topotype material containing his two species of *Aquilapollenites* from the Upper Cretaceous Brazeau formation of Alberta, Canada. They are *A. quadrilobus* and *A. trialatus*, the former being the type species of the genus. The lessons learned in studying the apertures of other species can be applied to these, and they appear to have apertures of the tridemicolpate type. In the light of the studies on the apertures of these and other species, it is necessary to emend the original generic description. Also, it must be extended to include variations other than those exhibited by Rouse's two species.

Aquilapollenites Rouse, emended

Angiosperm pollen that are either heteropolar or isopolar; one or both of the poles is extended into what may be called polar protrusions; three, often winglike, equatorial protrusions. Apertures of several types, often difficult to see in normal orientation; these are usually three colpi or three pairs of demicolpi borne on the outer margins of the equatorial protrusions. In addition, there may be three colpi on and parallel to the equator between the equatorial protrusions. Grains may be more or less smooth or sculptured (punctae, reticulae, spines, striae, etc.).



TEXT-FIGURE 1

DIAGRAMMATIC REPRESENTATIONS OF VARIOUS APERTURAL ARRANGEMENTS FOUND IN *Aquilapollenites*

The more coarsely shaded areas are polar or equatorial protusions that would be extending perpendicular to the plan of the diagrams. A, the isopolar tridemicolpate types, such as *Aquilapollenites spinulosus* and *A. attenuatus*; a, equatorial view; b, polar view. B, equatorial view of the heteropolar tridemicolpate types, such as *A. pulcher*, *A. polaris*, and *A. striatus*. C, the arrangement of the nine apertures in *A. novacolpites*; a, equatorial view; b, polar view. D, polar view of the tricolpate apertural arrangement of *A. bertillonites*.

Seven new species of *Aquilapollenites* are described below. In addition to these I have seen a number of others, but these have either been represented by poorly preserved material or have been in the collections of other workers.

Aquilapollenites spinulosus Funkhouser, new species
Plate 1, figures 4–6

Diagnosis Isopolar; three pairs of demicolpi; surface covered with randomly spaced spinules except for narrow bands paralleling demicolpi. Tip of equatorial protrusions to polar axis is about $\frac{1}{2}$ polar axis.

Isopolaris. Tria paria demicolporum. Praeter fascias angustas parallelas demicolpis, superficies tecta spinulis locatis fortuito. Ab ultima parte protrusorum aequatoris ad axem polarem est circum dimidium axis polaris.

Holotype: USNM 41310 (JPR 219–3) from the Fort Union formation (Paleocene), west flank of Rawlins Uplift, Rawlins, Wyoming (Sec. 11, T 21 N, R 89 W), pl. 1, fig. 4a–b.

Paratypes: USNM 41309 (JPR 219–1), USNM 41311 (JPR 220–1); same locality data, pl. 1, figs. 5–6.

Description: Isopolar; poles pulled out into prominent protrusions; three winglike equatorial protrusions; areas between the tips of the equatorial protrusions and the poles concave; along these concavities are borne the three pairs of demicolpi. Diameter of polar protrusions about $\frac{1}{3}$ polar axis; from the polar axis to the tip of an equatorial protrusion is about $\frac{1}{2}$ the polar axis; diameter of equatorial protrusions about $\frac{1}{3}$ polar axis. Except for narrow bands paralleling the demicolpi, entire surface covered by randomly spaced spinules; spacing, 1 to 2 times their basal diameter. Wall stratification obscure, but apparently nexine absent in bands paralleling demicolpi. Polar axis 33–35μ; from tips of equatorial protrusions to polar axis ca. 15μ.

Remarks: This species differs from *Aquilapollenites attenuatus* n. sp., in having shorter equatorial protrusions, no punctae, and its spinules are not grouped into definite areas as in the latter species.

Aquilapollenites spinulosus has so far been noted only from the Paleocene and Eocene of the Rocky Mountain area.

Aquilapollenites attenuatus Funkhouser, new species
Plate 2, figure 1a–c

Diagnosis: Isopolar with three pairs of demicolpi; equatorial protrusions about equal to polar axis; punctate with conical spinules in restricted areas.

PLATE 1

All figures magnified × 1000

1a–d *Aquilapollenites polaris* Funkhouser, n. sp. Equatorial view of holotype (four focus levels) USNM 41306.

2 *Aquilapollenites polaris* Funkhouser, n. sp. Proximal (?) polar view of paratype USNM 41307.

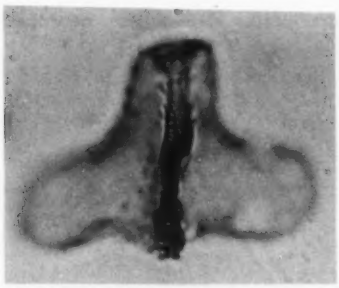
3 *Aquilapollenites polaris* (?) Funkhouser, n. sp. Proximal (?) polar view USNM 41312.

4a–b *Aquilapollenites spinulosus* Funkhouser, n. sp. Equatorial view of holotype (two focus levels) USNM 41310.

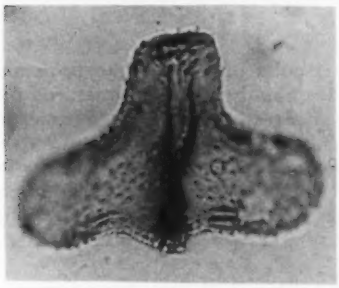
5 *Aquilapollenites spinulosus* Funkhouser, n. sp. Polar view of paratype USNM 41309.

6 *Aquilapollenites spinulosus* Funkhouser, n. sp. Polar view of paratype USNM 41311.

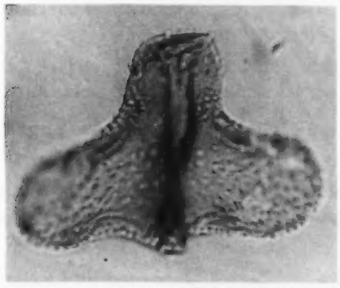
7a–c *Aquilapollenites pulcher* Funkhouser, n. sp. Equatorial view of holotype (7a, phase contrast; 7b–c, two focus levels) USNM 41305.



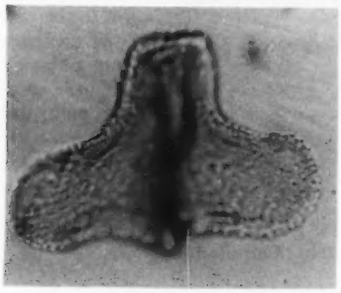
1a



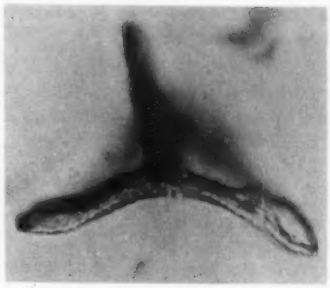
1b



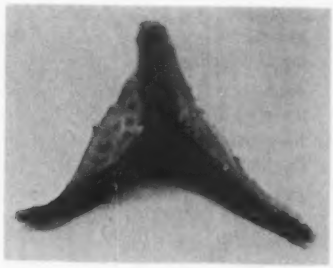
1c



1d

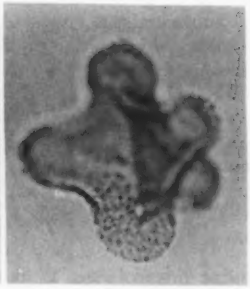


2

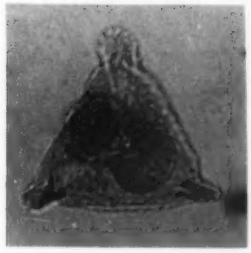


3

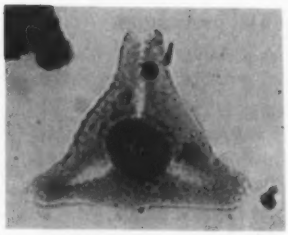
4a



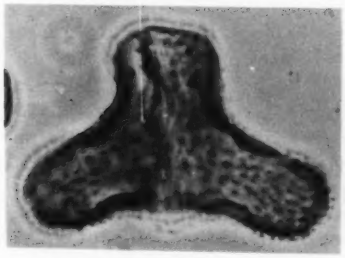
4b



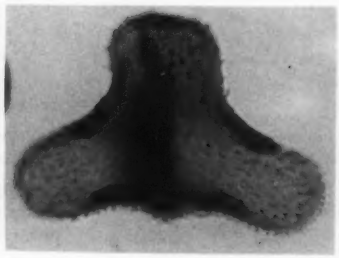
5



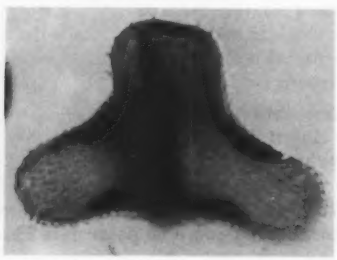
6



7a



7b



7c

Isopolaris cum tribus paribus demicolporum. Protrusa aequatoris circum aequa axi polari. Punctum cum spinulis conalis in areais definitis.

Holotype: USNM 41303 (JPR 214–1) from the Lance formation (Maestrichtian), west flank of Rawlins Uplift, Rawlins, Wyoming (Sec. 11, T 21 N, R 89 W), pl. 2, fig. 1a–c.

Description: Isopolar; poles pulled out into prominent protrusions; three winglike equatorial protrusions; areas between the tips of the equatorial protrusions and the poles concave; along these concavities are borne the three pairs of demicolpi. Diameter of polar protrusions about $\frac{1}{3}$ polar axis; a line drawn perpendicular to the polar axis and reaching to the tip of an equatorial protrusion is about equal to the polar axis; diameter of equatorial protrusions about $\frac{1}{3}$ polar axis.

Coarsely punctate; punctations more or less regular; diameter of lumina about equal to distance between. Conical spinules, whose basal diameter is slightly less than their length, are present on the polar protrusions, at the tips of the equatorial protrusions, and in a band along the center of the equatorial protrusions. This band widens as it approaches the central axis of the grain. Exine stratification obscure, but nexine apparently much thinner than sexine. Wall thickness not determined. Polar axis 43μ; tips of equatorial protrusions to polar axis 32μ.

Aquilapollenites novacolpites Funkhouser, **new species**
Plate 2, figures 2–3

Diagnosis: Isopolar; reticulate; tridemicolpate plus three furrows on and parallel to the equator between the equatorial protrusions.

Isopolaris. Reticulatus. Tridemicolpatus plus tres colpi super et paralleli aequatori inter protrusa aequatoris.

Holotype: USNM 41301 (JPR 213–1) from the Mesa Verde formation (Campanian), west flank of Rawlins Uplift, Rawlins, Wyoming (Sec. 6, T 21 N, R 88 W), pl. 2, fig. 2a–c.

Paratype: USNM 41302 (JPR 213–2); same locality data, pl. 2, fig. 3.

Description: Isopolar; poles pulled out into prominent, but blunt protrusions; three winglike equatorial protrusions which are constricted between their tips and the main body of the grain. Diameter of polar protrusions a little less than $\frac{1}{2}$ polar axis; from polar axis to tips of equatorial protrusions is about $\frac{2}{3}$ polar axis.

Tridemicolpate, the demicolpi occupying about the middle $\frac{1}{2}$ of the distance from the poles to the tips of the equatorial protrusions. In addition to the demicolpi, there are three furrows lying between the equatorial protrusions on and parallel to the equator.

Ornamentation a fine reticulum in which the lumina tend to be slightly elongate and are, on the average, slightly wider than the muri; tips of poles and ends of equatorial protrusions largely unornamented. Wall thickness and stratification not determined. Polar axis 35μ; tips of equatorial protrusions to polar axis 23μ.

Aquilapollenites bertillonites Funkhouser, **new species**
Plate 2, figure 5a–c

Diagnosis: Isopolar. Bertillon ornamentation; tricolpate, the colpi being at the tips of the equatorial protrusions; equatorial protrusions attenuated.

Isopolaris. Ornatus bertillonitis. Tricolpatus, colpis locatis ad ultimas partes protrusorum aequatoris. Protrusa aequatoris attenuata.

Holotype: USNM 41308 (JPR 218–1) from the Lance formation (Maestrichtian), west flank of Rawlins Uplift, Rawlins, Wyoming (Sec. 1, T 21 N, R 89 W), pl. 2, fig. 5a–c.

Description: Isopolar; poles pulled out into prominent protrusions; these are bluntly conical. Equatorial protrusions attenuated; between them are three equatorial bulges. Tricolpate, the colpi being short and located in the tips of the equatorial protrusions. Ornamentation a fingerprint, or Bertillon, pattern. Wall thickness and stratification not determined. From polar axis to tips of equatorial protrusions ca. 25μ; polar axis ca. 25μ.

Aquilapollenites striatus Funkhouser, **new species**
Plate 2, figure 4

Diagnosis: Heteropolar; tridemicolpate; striate, the striations being more or less parallel to the polar axis.

Heteropolaris. Tridemicolpatus. Striatus, striae fere parallelae axi polari.

Holotype: USNM 41304 (JPR 215–1) from the Lance formation (Maestrichtian), west flank of Rawlins Uplift, Rawlins, Wyoming (Sec. 1, T 21 N, R 89 W), pl. 2, fig. 4.

Description: Heteropolar; one pole extended into a slight protrusion; the other concave with relation to the three winglike equatorial protrusions; diameter of protruded pole about $\frac{1}{2}$ the polar axis; distance from polar axis to tip of equatorial protrusions about $1\frac{1}{4}$ the polar axis; their diameter a little less than $\frac{1}{2}$ the polar axis; equatorial protrusions slant away from the polar protrusion, making about a 50° angle with the polar axis.

PLATE 2
All figures magnified × 1000

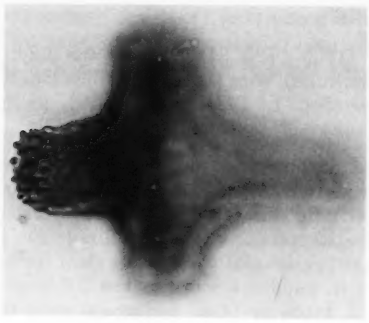
1a–c *Aquilapollenites attenuatus* Funkhouser, n. sp. Equatorial view of holotype (three focus levels) USNM 41303.

2a–c *Aquilapollenites novacolpites* Funkhouser, n. sp. Equatorial view of holotype (three focus levels) USNM 41301.

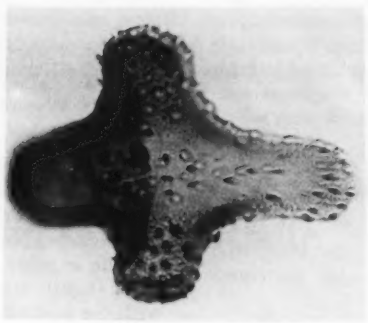
3 *Aquilapollenites novacolpites* Funkhouser, n. sp. Equatorial view of paratype USNM 41302.

4 *Aquilapollenites striatus* Funkhouser, n. sp. Equatorial view of holotype USNM 41304.

5a–c *Aquilapollenites bertillonites* Funkhouser, n. sp. Diagonal view of holotype (three focus levels; polar axis is vertically oriented) USNM 41308.

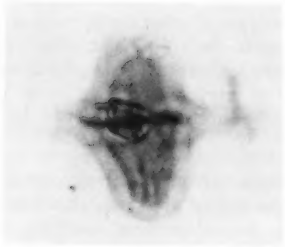


1a

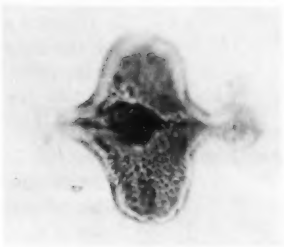


1b

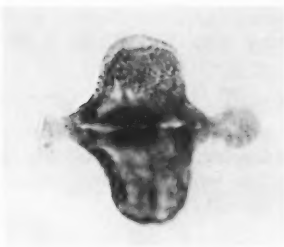
1c



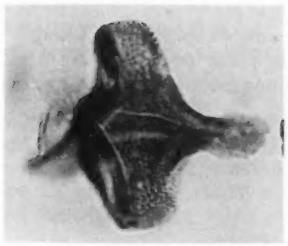
2a



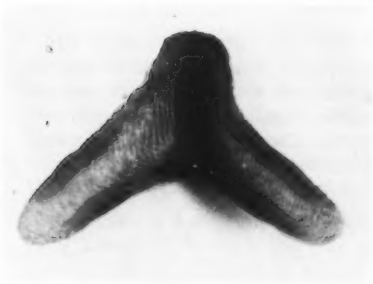
2b



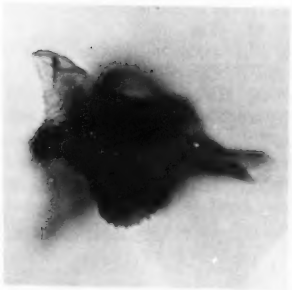
2c



3



4



5a

5b

5c

Irregularly striate, the striations being more or less parallel to the polar axis. Tridemicolpate, the demicolpi being located on the polar margins of the equatorial protrusions; these appear as thickened areas in lateral view. Exine stratification obscure; wall thickness not determined. Polar axis 24μ; tip of equatorial protrusion to polar axis 30μ.

Aquilapollenites polaris Funkhouser, new species
Plate 1, figures 1–2

Diagnosis: Heteropolar; spinulose and punctate; tridemicolpate; apertural areas covered with punctae; may be syncolpate at reduced pole.

Heteropolaris. Spinulosus plus punctatus. Tridemicolpatus. Areae apertorum tectae punctis. Sit syncolpatus ad polum reductum.

Holotype: USNM 41306 (JPR 216–1) from the Lance formation (Maestrichtian), west flank of Rawlins Uplift, Rawlins, Wyoming (Sec. 1, T 21 N, R 89 W), pl. 1, fig. 1a–d.

Paratype: USNM 41307 (JPR 216–3); same locality data, pl. 1, fig. 2.

Description: Heteropolar; one pole bluntly conical and protruded above the equatorial protrusions; the other makes only the slightest convexity below the equatorial protrusions; protruded pole less than $\frac{1}{2}$ polar axis and not as wide as equatorial protrusions. Equatorial protrusions slant backward from their midline making a more or less 30° angle with the polar axis. From tip of equatorial protrusion to polar axis is about $\frac{2}{3}$ polar axis.

Tridemicolpate; demicolpi begin at a point about halfway from the tips of equatorial protrusions to where they meet the main body of the grain, and extend almost to protruded pole; they may meet at the reduced pole to be syncolpate. The wall is locally thickened in the apertural areas and appears to be tegillate.

Spinules on ends of polar protrusions; on equatorial protrusions the spinules are confined to a median band where the protrusions join the body of the grain, but expand to cover the entire protrusions at their ends. Spinules of polar protrusions coarser and more widely spaced than those of equatorial protrusions. Former directed more or less poleward; those of latter directed away from tip toward polar axis. The polar protrusions are covered with coarse punctae which extend along the polar edges of the equatorial protrusions almost to their tips. The punctate areas include the locally thickened areas bordering the demicolpi. Wall thickness and stratification not determined except for possible tegillum along demicolpi. Polar axis 34μ; tip of equatorial protrusions to polar axis 25μ.

Aquilapollenites pulcher Funkhouser, new species
Plate 1, figure 7a–c

Diagnosis: Heteropolar; spinulose and punctate; tridemicolpate; apertural areas devoid of ornamentation.

Heteropolaris. Spinulosus plus punctatus. Tridemicolpatus. Areae apertorum vacuae ornatu.

Holotype: USNM 41305 (JPR 215–6) from the Lance formation (Maestrichtian), west flank of Rawlins Uplift, Rawlins, Wyoming (Sec. 1, T 21 N, R 89 W), pl. 1, fig. 7a–c.

Description: Heteropolar; one pole more or less rectangular in plane view and protruded above equatorial protrusions. The other pole shows only a slight convexity below the equatorial protrusions. Protruded pole ca. $\frac{1}{2}$ as wide as polar axis; equatorial protrusions slant backward slightly from it, making a more or less 20° angle with the polar axis. From tip of an equatorial wing to polar axis is $\frac{1}{3}$ polar axis.

Tridemicolpate; demicolpi relatively short and confined to areas of local wall thickening. These start where the equatorial protrusions meet the main body of the grain and extend along their polar surfaces for a little less than half the distance to their tips. The areas of wall thickening involved here appear to be completely unornamented laterally (in the preparations we have made of this species, these areas are the only part of the grain to take stain).

Most of the grain covered with spinules; those of the polar areas are larger and more widely spaced than those of the equatorial protrusions. The former tend to project more or less poleward until the tips of the poles are reached, where they are more or less perpendicular to the surface; those of the equatorial protrusions project backwards toward the polar axis. The area of the short polar protrusion is more or less covered by punctae in addition to spinules. A band of punctae surrounds the long polar protrusion from where the equatorial protrusions meet it to a point about halfway to its tip.

Wall thickness and exine stratification not determined. Polar axis 32μ; tip of equatorial protrusions to polar axis 25μ.

BIBLIOGRAPHY

KRUTZSCH, W.
1957 – *Sporen- und Pollengruppen aus der Oberkreide und dem Tertiär Mitteleuropas und ihre stratigraphische Verteilung.* Angew. Geol., Zeitschr., vol. 3, no. 11–12, pp. 509–548, pls. 1–16, 2 charts, 1 map.

POKROVSKAYA, I. M., (ED.)
1956 – *Atlas of Oligocene spore-pollen complexes of various regions of the USSR.* Government Scientific and Technical Publishing House for the Literature in Geologic Security and Mineral Resources, vol. 16, 312 pp., 47 pls., 2 maps, 3 charts.

ROUSE, G. E.
1957 – *The application of a new nomenclatural approach to Upper Cretaceous plant microfossils from western Canada.* Canadian Jour. Bot., vol. 35, pp. 349–375, pls. 1–3.

THOMSON, P. W., and PFLUG, H.
1953 – *Pollen und Sporen des Mitteleuropäischen Tertiärs.* Palaeontographica, part. B, vol. 94, no. 1–4, pp. 1–138, pls. 1–15, text figs. 1–18, 1 chart.

ABSTRACT

One hundred and twenty bottom samples were collected from 24 stations surrounding the Orange County ocean sewer outfall. Two zones of depth distribution were determined; an intertidal zone from 0 to 20 feet and an upper sublittoral zone from 20 to 78 feet. The manner in which the effects produced by the outfall influence the foraminifera is discussed.

Foraminiferal ecology around the Orange County, California, ocean sewer outfall

JAMES G. WATKINS
Department of Geology
University of Southern California
Los Angeles, California

INTRODUCTION

Along the coast of southern California, the most effective way to dispose of man's inevitable waste is by means of ocean sewer outfalls. Residents, fishermen, health authorities, and scientists are naturally concerned with the effects of the outfalls upon the waters and beaches of the surrounding areas.

To the knowledge of the writer, no detailed study has been undertaken to show the effects of the outfalls upon the benthonic foraminifera living on the ocean floor around the terminus. With this in mind, a concentrated study of the area around the ocean outfall of the County Sanitation Districts of Orange County, California, was made.

The area under consideration includes that part of the continental shelf which lies between the cities of Huntington Beach and Newport Beach, California. It extends seaward from the coastline a distance of approximately four miles (text-fig. 1).

The outfall for the disposal of sewage by the County Sanitation Districts of Orange County terminates in the center of the area 7,000 feet off-shore from the mouth of the Santa Ana River. Approximately 25,000,000 gallons of effluent is discharged daily into the ocean.

A network of station locations has been established by the county in the region surrounding the outfall. Samples of water are taken daily for bacterial and chemical analyses. The stations are located on north-south and east-west lines with a spacing of 1500 feet. Bottom samples from 16 of these stations were collected several times during the year. In addition, samples were taken from the piers at Huntington Beach and Newport Beach. Two samples from the collections of the Allan Hancock Foundation of the University of Southern California have been used. The location of all stations is shown in text-figure 2.

A Petersen type grab sampler was used to obtain the bottom samples. The samples were placed in pint jars, and isopropyl alcohol and Rose Bengal solution added.

Identification of living and dead foraminifera was made for each of the 120 samples collected. If the concentrated sample was large, it was split a number of times until a countable fraction of about 500 specimens was obtained.

Although this study is the first detailed investigation dealing specifically with ocean outfalls, several important ecological studies have been undertaken on the foraminifera along the coast of southern California.

Natland (1933) determined five faunal zones from sea level to a depth of 8,000 feet along a profile extending from Long Beach, California to Santa Catalina Island. Foraminifera from cores taken from the off-shore basins of southern California were studied by Crouch (1952). Bandy (1953) studied the distribution of the foraminifera along three profiles extending across the shelf of southern, central and northern California. Walton (1955) reported on the foraminifera of Santos Todos Bay, Baja California. Resig (1958*a*) investigated the distribution of living foraminifera in the Santa Cruz Basin off southern California.

In a paper dealing closely with the present study, Zalesny (1959) reported on the foraminiferal ecology of Santa Monica Bay. Reiter (1959) studied the seasonal variations of living foraminifera in the intertidal zone around Santa Monica Bay.

Presently, Resig is working on the foraminifera of the continental shelf from Point Conception to the Mexican border. Some of her samples were taken in the vicinity of several ocean outfalls. Preliminary results of her investigations appear in unpublished reports to the State Water Pollution Control Board by the Allan Hancock Foundation of the University of Southern California (Resig, 1958*b*).

ACKNOWLEDGMENTS

The writer wishes to thank Mr. William H. Henderson, Chief Chemist of the County Sanitation Districts of Orange County, California, for furnishing the equipment necessary for the collection of samples and for allowing ship time. Thanks are also due to Mr. Fred Munson, owner of the motor launch *Enchanter* III, for his assistance in the collection of samples. Drs. Richard O. Stone and Richard H. Merriam of the Geology Department of the University of Southern California read the manuscript and offered helpful advice. The writer is especially grateful to Dr. Orville L. Bandy of the Geology Department of the University of Southern California who suggested the topic and willingly gave valuable assistance and advice throughout the study.

OCEANOGRAPHIC CONDITIONS

The continental shelf in the area under consideration is approximately 8 miles wide, but to the north and south, the shelf narrows to a mile or two in width. The shelf slopes uniformly at the rate of approximately 30 feet per mile to the shelf break, which is located at a water depth of approximately 48 fathoms.

The shelf sediments consist of fine to very fine olive green to gray quartz feldspar sand with abundant mica and small amounts of glauconite. Quartz is the dominant mineral, making up more than 50% of each sample.

Inasmuch as all samples were sand size, grain size analyses were made by means of the Emery settling tube (Emery, 1938). A plot of average median diameters of the sand grains shows coarser sediments in the immediate area of the outfall (text-fig. 3). This condition may be attributed to two factors. First, the effluent issuing from the outfall creates turbulence causing winnowing out of the finer particles. Secondly, the Santa Ana River contributes coarser sediment to the area than is normally found along the shelf at equivalent depths.

Along the outer edge of the shelf is the southerly flowing California Current. This current is strongly influenced by the unique structure of the sea floor off southern California (Emery, 1941). The California Current is modified to such an extent that oceanic waters seldom carry across the shelf. Friction and barrier effects control the movement near shore. Unusual eddies, counter flows and turbulence flows are set up which are not constant for long periods of time. Wind is considered the most important factor in generating near-shore currents.

From drift cards released in the vicinity of the outfall from July to September, 1958, it was discovered that the surface movement of water is generally downwind at a velocity of 2% to 3% of that of the wind (Stevenson, 1958). Since the prevailing wind is from the west to northwest, most of the surface water moves east to southeast or about parallel to the coastline.

Two types of temperature profiles are exhibited in the depth range under consideration. In summer, the surface layer is heated, thus producing a layer of relatively warm water overlying the cooler subsurface water. In contrast, during the winter months little change takes place from top to bottom. These two types of profiles, as observed at station S during the study, are shown in text-figure 4.

Surface salinity in the vicinity of the outfall is slightly lower than normal. No measurement of salinity at depth was made. The rate of variation would be much less at depth than at the surface, because the lower salinity effluent rises to the surface and spreads out in a thin film. Measurements made at a depth of 45 feet in 1955 showed a variation of only 0.04 parts per thousand (Rittenberg, and others, 1956).

Compounds of phosphorous, silicon, and nitrogen are of the utmost importance in the metabolic processes of plants and animals. Measurement of the amount of nutrient salts of these elements in the vicinity of the outfall has shown that the concentration is greater near the outfall, but decreases rapidly with distance from the outfall, so that at a distance of 3,000 feet from the outfall the values are near normal. Average nutrient values around the outfall as determined in December, 1955, is given in text-figure 5 (after Stevenson & Grady, 1956).

FORAMINIFERA

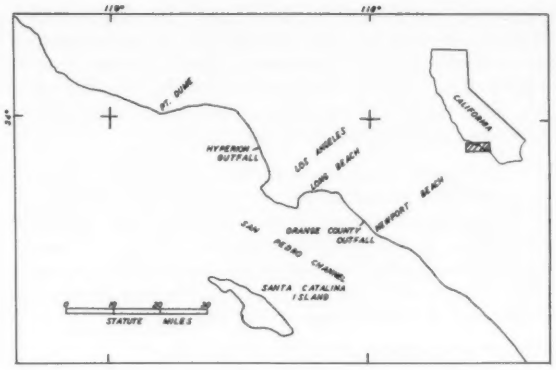
General Distribution

Fifty-two species of benthonic foraminifera were identified. Two depth distribution zones were determined; an intertidal zone from 0 to 20 feet and the upper sublittoral zone from 20 to 78 feet. The dominant species of the two zones are listed in Table 1.

Resig has determined five zones of foraminifera along the coast of southern California (Table 2). In a comparison with her zonation, some important differences are noted in the region around the outfall. The most striking deviation from the normal occurs in the distribution of the arenaceous species. *Eggerella advena* normally appears in abundance on the Central Shelf at a depth of 100 to 250 feet. However, in the area around the outfall this species occurs in abundance in much shallower water. Similarly, *Alveolophragmium columbiensis* and *Trochammina pacifica* occur in abundance in shallower water than they normally inhabit. The effect of the outfall in increasing the percentage of arenaceous species is represented in text-figure 6. The areal distribution of the arenaceous species is shown by text-figure 7.

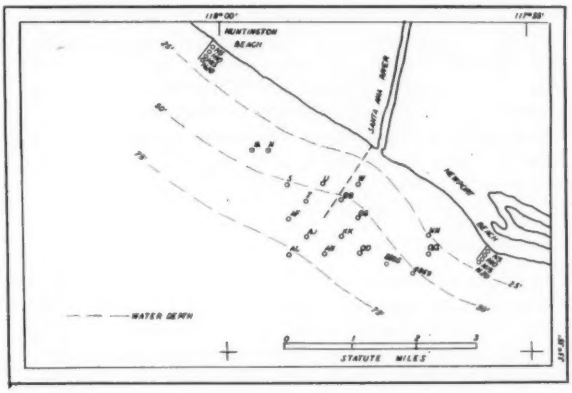
Frequency distribution

A frequency distribution profile (text-fig. 8) through the end of the outfall and on a line approximately parallel to the coastline reveals some interesting phenomena.



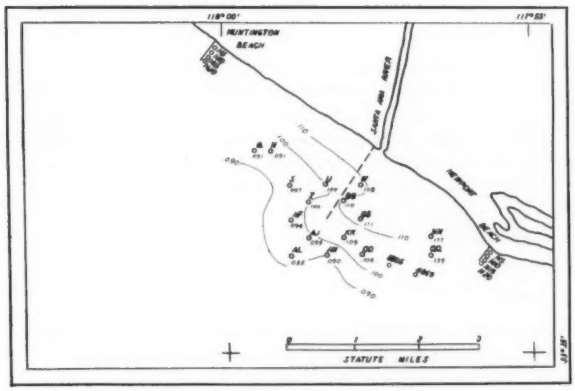
TEXT-FIGURE 1

Index map showing location of Orange County sewer outfall.



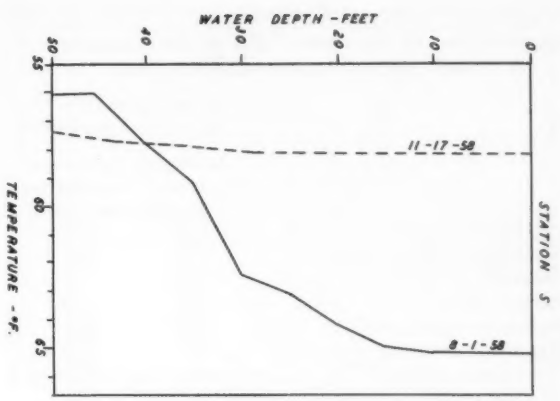
TEXT-FIGURE 2

Location of stations.



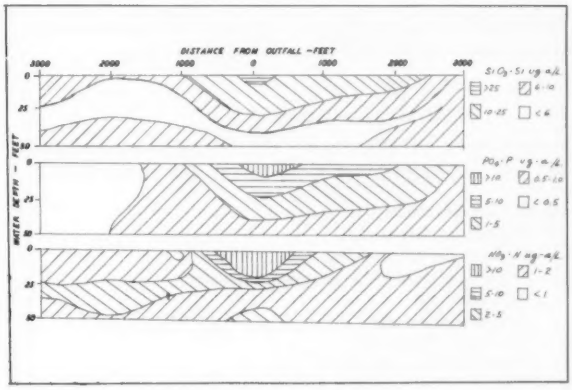
TEXT-FIGURE 3

Average grain size of sediments in mm.



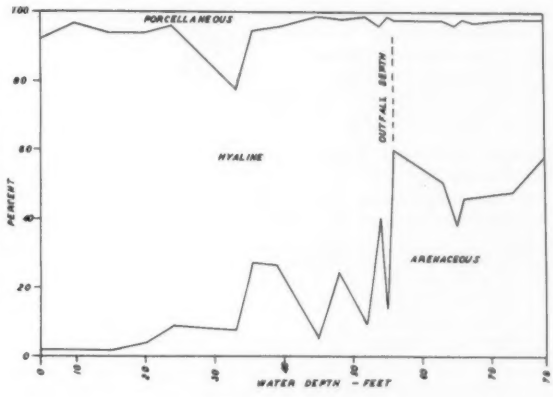
TEXT-FIGURE 4

Temperature-depth curves for winter and summer.



TEXT-FIGURE 5

Nutrient salt concentration surrounding the Orange County outfall in December, 1955 (after Stevenson and Grady, 1956).



TEXT-FIGURE 6

Frequency distribution of test types versus depth of water.

TABLE 1

DISTRIBUTION OF SIGNIFICANT SPECIES OF FORAMINIFERA AROUND THE ORANGE COUNTY OUTFALL

	Average percent of living and dead population	
	Intertidal zone	Upper sublittoral zone
	0–20 feet	20–78 feet
Elphidium translucens	43.9	8.6
Tretomphalus myersi	11.8	0.5
Rotorbinella lomaensis	7.9	0.5
Cibicides fletcheri	1.9	0.0
Buliminella elegantissima	11.4	46.0
Eggerella advena	0.1	14.0
Trochammina pacifica	1.9	10.2
Alveolophragmium columbiensis	0.1	6.0
Saccammina atlantica	0.0	1.7
Nonionella basispinata	4.9	3.6
Quinqueloculina akneriana	4.9	3.3

Species which are underlined in the percent columns are the characteristic marker species for the respective zone.

TABLE 2

DISTRIBUTION OF SIGNIFICANT SPECIES OF FORAMINIFERA OFF THE SOUTHERN CALIFORNIA COAST (after Resig, 1958*b*)

NEARSHORE (less than 100 feet in depth)
- *Buliminella elegantissima*
- *Cibicides fletcheri*
- *Discorbis monicana (Tretomphalus myersi)*
- *Elphidium spp.*
- *Quinqueloculina spp.*
- *Rotorbinella lomaensis*
- *Trochammina squamiformis*

NEARSHORE and CENTRAL SHELF
- *Buccella frigida*
- *Alveolophragmium columbiensis*
- *Saccammina atlantica*
- *Trochammina pacifica*

CENTRAL SHELF (100–250 feet)
- *Eggerella advena*
- *Haplophragmoides advena*
- *Nonionella basispinata*
- *Nonionella miocenica* var. *stella*
- *Reophax scorpiurus*

CENTRAL and OUTER SHELF
- *Goesella flintii*
- *Textularia earlandi*
- *Virgulina seminuda*

OUTER SHELF (250–300 feet)
- *Angulogerina spp.*
- *Bolivina acuminata*
- *Bolivina pacifica*
- *Bulimina denudata*
- *Cassidulina spp.*
- *Epistominella bradyana*
- *Gaudryina arenaria*
- *Pullenia salisburyi*
- *Uvigerina juncea*

It can be seen that a significant increase in the combined arenaceous species, *Eggerella advena*, *Alveolophragmium columbiensis*, and *Trochammina pacifica* occurs in the vicinity of the outfall. The presence of the outfall probably accounts for the increase, as the water depth does not change appreciably along this profile.

In a frequency distribution profile through the end of the outfall and perpendicular to the coastline (text-fig. 9), a greater difference is expressed by the relative percentages of the dominant species. Again, a large increase is observed in the arenaceous species in the outfall region. However, most of the increase is due to an increase in water depth along this profile.

Intertidal zone

The foraminifera of the intertidal zone consist almost entirely of hyaline and porcellaneous species. *Elphidium translucens* is the dominant species, comprising more than 50% of the total population in some samples (text-fig. 10). *Tretomphalus myersi*, *Rotorbinella lomaensis*, and *Cibicides fletcheri* are characteristic species of the zone; they occur in abundance in this zone yet rarely exceed 1% of the total population outside of this zone. Only one arenaceous species, *Trochammina pacifica* was discovered living in the zone, and this one was present only in small numbers.

Upper sublittoral zone

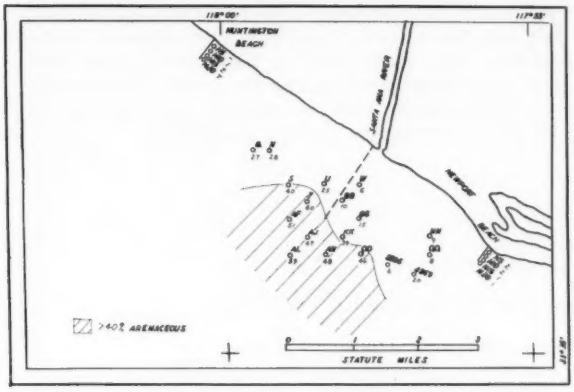
The upper sublittoral zone includes all of the stations in the area except the stations located along the two piers. *Buliminella elegantissima* is the dominant species out to a depth of approximately 60 feet (text-fig. 11). Arenaceous species are the most important constituents of the foraminiferal assemblage in the depth range of 60 to 78 feet (text-fig. 7). *Trochammina pacifica* (text-fig. 12), *Eggerella advena* (text-fig. 13), *Alveolophragmium columbiensis*, and *Sacammina atlantica* are the characteristic marker species for the upper sublittoral zone.

Foraminiferal number

The foraminiferal number is defined as the total number of living and dead foraminifera present in one gram of dry sediment. In the immediate area around the outfall, this number increases two to three times the normal along the remainder of the shelf off southern California (text-fig. 14). The anomalous condition which exists at the outfall is brought out by the contours of the foraminiferal number.

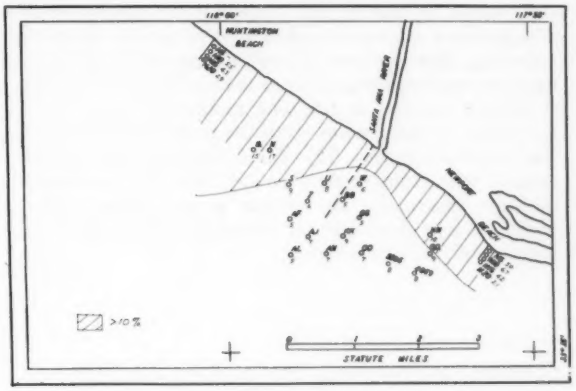
Size variations

Two species, *Buliminella elegantissima* and *Trochammina pacifica* were measured with an ocular micrometer to determine variations near the outfall. These species were selected because of their abundance in almost every sample. Only the living specimens were measured and the maximum size in each sample was recorded.



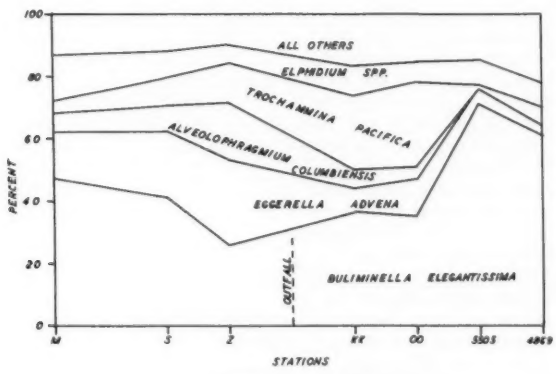
TEXT-FIGURE 7

Average percentage of living and dead arenaceous species.



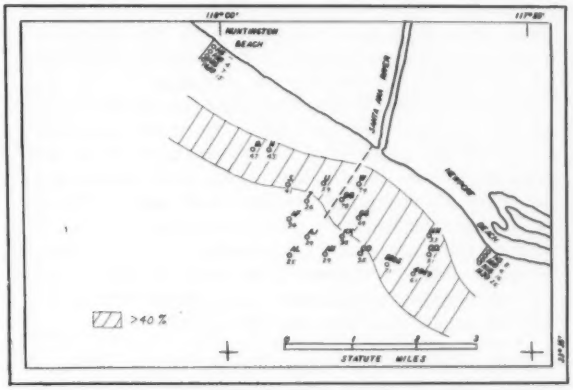
TEXT-FIGURE 10

Average percent of living and dead *Elphidium translucens*.



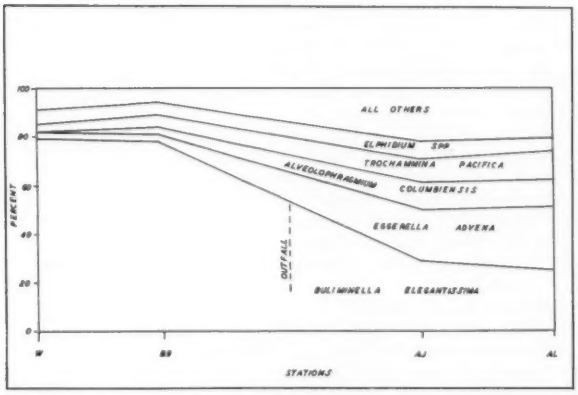
TEXT-FIGURE 8

Frequency distribution along profile parallel to coastline.



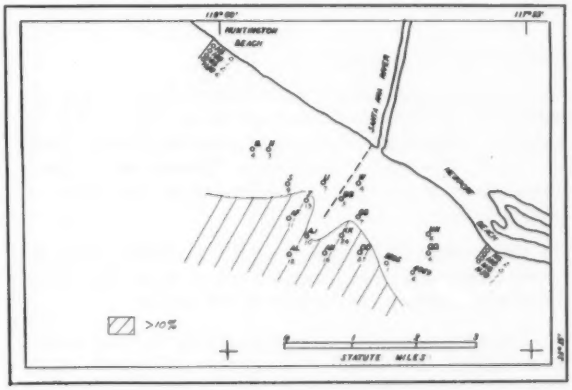
TEXT-FIGURE 11

Average percent of living and dead *Buliminella elegantissima*.



TEXT-FIGURE 9

Frequency distribution along profile perpendicular to coast.



TEXT-FIGURE 12

Average percent of living and dead *Trochammina pacifica*.

The range in size of the largest living specimens of *Trochammina pacifica* recorded at each station for each collecting date has been plotted against depth of water, and also against distance from the outfall (text-fig. 15). A definite increase in size with increasing water depth is evident. A comparison with the areal distribution of this species (text-fig. 12) shows that the percentage relative to the total population also increases with depth of water. From the plot of size versus distance from outfall, it is evident that the outfall has little effect on the size of the individuals.

Abnormality

In making the percentage counts of the species, it was observed that some species exhibited abnormal characteristics in some of the samples. To determine the effect of the outfall upon these species, every sample was studied and the kind and number of abnormal foraminifera were determined. The most abundant of these were *Elphidium spinatum*, which has additional spines on some specimens, and *Nonionella basispinata*, which exhibits abnormality in the shape of the test. The total number of abnormal *Elphidium spinatum* (text-fig. 16) is greater near the outfall. Since this species did not constitute more than 2% of the total living and dead population in any one sample and inasmuch as nearly equal amounts of sediment were used in preparing the samples for study, the number plotted may be used to indicate relative differences in the abnormal forms at different stations. The total number of abnormal *Nonionella basispinata* at each station (text-fig. 17) shows a similar increase near the outfall.

A study of abnormal foraminifera by Arnal (1955) indicated that no abnormal specimens of foraminifera were recorded from samples collected in shallow water environments on an open coast. From this, it is evident that the outfall has a direct influence upon the occurence of abnormal foraminifera.

SUMMARY AND CONCLUSIONS

The distribution of benthonic foraminifera in the vicinity of the Orange County outfall is quite different from the normal distribution at equivalent depths along the shelf of southern California. Trends which have been observed that are primarily due to the effects of the outfall are:

1) The number of living and dead foraminifera in each gram of dry sediment increases two to three times the normal number in the vicinity of the outfall.

2) Arenaceous species have an affinity for the water surrounding the outfall and inhabit shallower water than they normally occupy.

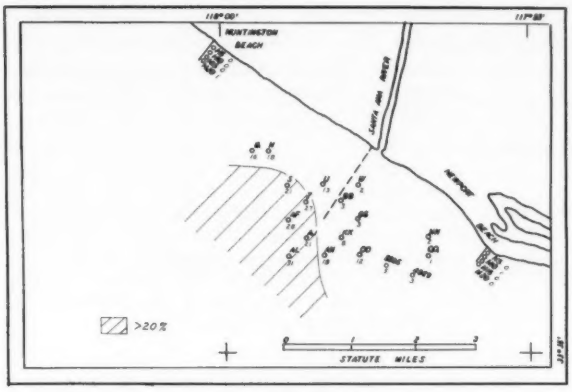
3) Abnormality of some species shows a marked increase in the area surrounding the outfall.

The increase in the foraminiferal number near the outfall may be directly related to the increase in the nutrient salts. Measurements have shown that these salts are concentrated around the outfall. Phytoplankton thrive under these conditions, and provide an abundant food supply for the foraminifera.

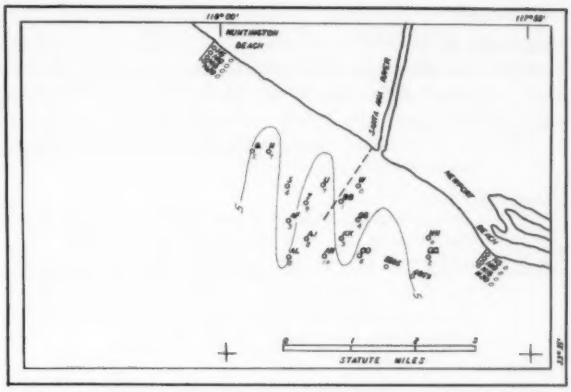
FAUNAL REFERENCE LIST

Asterisks are used to denote living species.

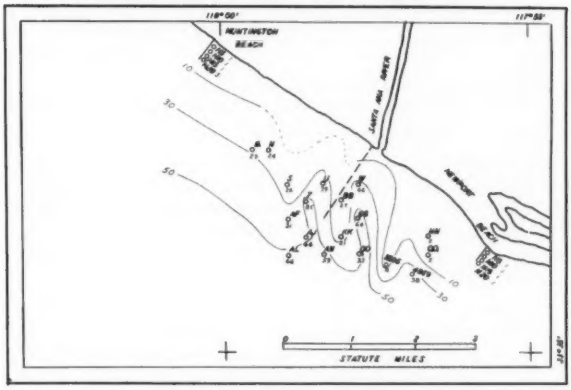
**Alveolophragmium columbiensis* (Cushman)
Angulogerina semitrigona (Galloway and Wissler)
Bolivina acerosa Cushman *var. pacifica* Cushman and McCulloch
**Bolivina quadrata* Cushman and McCulloch
**Buccella frigida* (Cushman)
**Bulimina denudata* Cushman and Parker
Bulimina elongata d'Orbigny
**Buliminella elegantissima* (d'Orbigny)
**Cibicides fletcheri* Galloway and Wissler
**Cibicides lobatus* (Montagu)
**Cornuspira involvens* (Reuss)
Dentalina baggi Galloway and Wissler
**Eggerella advena* (Cushman)
**Elphidium articulatum* (d'Orbigny)
**Elphidium spinatum* Cushman and Valentine
**Elphidium translucens* Natland
**Elphidium tumidum* Natland
**Fissurina lateralis* (Cushman)
**Fissurina lucida* (Williamson)
**Goesella flinti* Cushman
**Haplophragmoides advena* Cushman
**Lagena amphora* Reuss
Lagena gracillima (Seguenza) *var. mollis* Cushman
Lagena hispidula Cushman
Lagena laevis (Montagu)
Lagena striata (d'Orbigny)
**Lagena substriata* Williamson
**Massilina pulcherrima* Cushman and Valentine
**Massilina robustior* Cushman and Valentine
**Nonionella basispinata* (Cushman and Moyer)
**Nonionella miocenica* Cushman *var. stella* Cushman and Moyer
Polymorphina problema d'Orbigny
**Quinqueloculina akneriana* d'Orbigny
Quinqueloculina bosciana d'Orbigny
**Quinqueloculina rhodiensis* Parker
**Reophax communis* Lacroix
Reophax scorpiurus Montfort
Reophax scottii Chaster, 1892
Robertina charlottensis (Cushman)
**Rotorbinella lomaensis* (Bandy)
**Saccammina atlantica* (Cushman)
**Sigmomorphina praelonga* (Egger)
**Spiroloculina depressa* d'Orbigny *var. californica* Cushman and Todd
**Streblus tepidus* (Cushman)
**Textularia earlandi* Parker
Textularia schencki Cushman and Valentine
**Tretomphalus myersi* Cushman
Triloculina tricarinata d'Orbigny
**Triloculina trigonula* (Lamarck)
**Trochammina pacifica* Cushman
Virgulina semiduda Natland



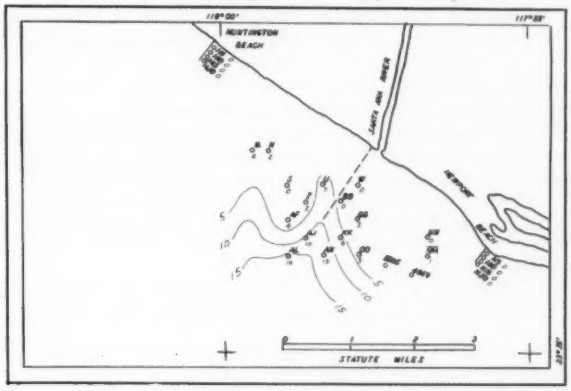
TEXT-FIGURE 13
Average percent of living and dead *Eggerella advena*.



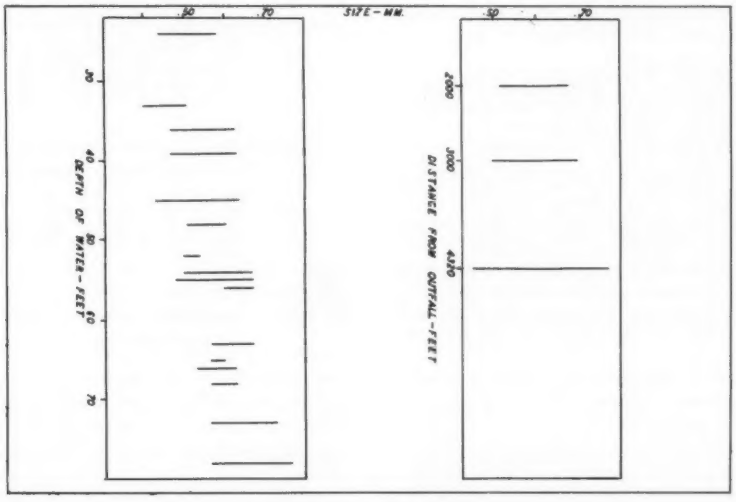
TEXT-FIGURE 16
Number of abnormal specimens of *Elphidium spinatum*.



TEXT-FIGURE 14
Average number of living and dead foraminifera per gram of sediment.



TEXT-FIGURE 17
Number of abnormal specimens of *Nonionella basispinata*.



TEXT-FIGURE 15
Size range of living species of *Trochammina pacifica* versus water depth and versus distance from outfall.

BIBLIOGRAPHY

ANDERSEN, H. V.
1952 – *Buccella, a new genus of the rotalid foraminifera.* Washington Acad. Sci., Jour., vol. 42, no. 5, pp. 143–151.

ARNAL, R. E.
1955 – *Some occurrences of abnormal foraminifera.* The Compass, vol. 32, pp. 185–194.

BANDY, O. L.
1953 – *Ecology and paleoecology of some California foraminifera, Part I.* Jour. Pal., vol. 27, no. 2, pp. 161–182.

CROUCH, R. W.
1952 – *Significance of temperature on foraminifera from deep basins off southern California coast.* Amer. Assoc. Petr. Geol., Bull., vol. 36, no. 5, p p. 807–843.

CUSHMAN, J. A.
1927 – *Recent Foraminifera off the west coast of America.* California, Univ., Scripps Inst. Oceanogr., Bull., Tech. Ser., vol. 1, no. 10, pp. 119–188.

CUSHMAN, J. A. and MCCULLOCH, I.
1939 – *A report on some arenaceous Foraminifera.* Southern California, Univ., Publ., Allan Hancock Pacific Exped., vol. 6, no. 1, pp. 1–113.

1940 – *Some Nonioni dae in the collections of the Allan Hancock Foundation.* Ibid., vol. 6, no. 3, pp. 145–178.

1942 – *Some Virgulinidae in the collections of the Allan Hancock Foundation.* Ibid., vol. 6, no. 4, pp. 179–230.

1948 – *The species of Bulimina and related genera in the collections of the Allan Hancock Foundation.* Ibid., vol. 6, no. 5, pp. 231–294.

CUSHMAN, J. A. and MOYER, D. A.
1930 – *Some Recent foraminifera from off San Pedro, California.* Cushman Lab. Foram. Res., Contr., vol. 6, pt. 3, pp. 49–62.

CUSHMAN, J. A., and VALENTINE, W. W.
1930 – *Shallow-water foraminifera from the Channel Islands of southern California.* Stanford Univ., Dept. Geol., Contr., vol. 1, no. 1, pp. 1–31.

EMERY, K. O.
1938 – *Rapid method of mechanical analysis of sands.* Jour. Sed. Petrol., vol. 8, no. 3, pp. 105–111.

LALICKER, C. G. and MCCULLOCH, I.
1940 – *Some Textulariidae of the Pacific Ocean.* Southern California, Univ., Publ., Allan Hancock Pacific Exped., vol. 6, no. 2, pp. 115–143.

NATLAND, M. L.
1933 – *The temperature and depth distribution of some Recent and fossil foraminifera in the southern California region.* California, Univ., Scripps Inst. Oceanogr., Bull., Tech. Ser., vol. 3, no. 10, pp. 225–230.

1938 – *New species of foraminifera from off the west coast of North America and from the later Tertiary of the Los Angeles Basin.* California, Univ., Scripps Inst. Oceanog., Bull., Tech. Ser., vol. 4, no. 5, pp. 137–164.

REITER, M.
1959 – *Seasonal variations in intertidal foraminifera of Santa Monica Bay, California.* Jour. Pal., vol. 33, no. 4, pp. 606–630.

RESIG, J. M.
1958*a* *Ecology of foraminifera of the Santa Cruz Basin, California.* Micropaleontology, vol. 4, no. 3, pp. 287–308.

1958*b* *Microbiology of the mainland shelf of southern California.* In: *Survey of the continental shelf area of southern California.* Unpublished report submitted to the California State Water Pollution Control Board by the Allan Hancock Foundation of the University of Southern California, 559 pp.

RITTENBERG, S. C. and others
1956 – *The distribution of coliform bacteria in the waters surrounding the Orange County sewer outfall.* Unpublished report submitted to the County Sanitation Districts of Orange County, California by the Allan Hancock Foundation of the University of Southern California, 42 pp.

SHEPARD, F. P. and EMERY, K. O.
1941 – *Submarine topography off the California coast.* Geol. Soc. Amer., Spec. Paper 31, 171 pp.

STEVENSON, R. E. and GRADY, J. R.
1956 – *Plankton and associated nutrients in the waters surrounding three sewer outfalls in southern California.* Unpublished report submitted to Hyperion Engineers, Inc. by the Geology Dept. Univ. Southern California, 48 pp.

STEVENSON, R. E. and Others
1958 – *Oceanographic survey of the continental shelf area of southern California.* Unpublished report submitted to the California State Water Pollution Control Board by the Allan Hancock Foundation of the University of Southern California, 560 pp.

STEVENSON, R. E.
1958 – *Drift card studies on the Newport Shelf, July through September, 1958.* Unpublished report submitted to the County Sanitation Districts of Orange County, California by the Allan Hancock Foundation of the University of Southern California, 31 pp.

WALTON, W. R.
1952 – *Techniques for the recognition of living foraminifera.* Cushman Found. Foram. Res., Contr., vol. 3, pt. 2, pp. 56–60.

1955 – *Ecology of living benthonic foraminifera, Todos Santos Bay, Baja California.* Jour. Pal., vol. 29, no. 6, pp. 952–1018.

ZALESNY, E. R.
1959 – *Foraminiferal ecology of Santa Monica Bay, California.* Micropaleontology, vol. 5, no. 1, pp. 101–126.

ABSTRACT

The Indiana paper coal contains plant microfossils identifiable as Bicoloria *Horst and* Torispora *Balme. The sporangium* Bicoloria *consists of an outer layer of* Torispora *and an interior mass of membraneous spores. The sporangia, when found in clusters, are attached to each other at their pointed ends and are therefore thought to have been pendant. The name* Bicoloria *is restricted to intact sporangia, and the name* Torispora *is retained for isolated, dispersed spores. The range of* Torispora securis *is extended downward to include the upper Pottsville strata of Indiana (Westphalian B).*

Torispora securis Balme: Spore or sporangial wall cell?*

G. K. GUENNEL AND R. C. NEAVEL
Indiana Geological Survey
Bloomington, Indiana

INTRODUCTION

The Indiana paper coal (Neavel and Guennel, 1958) contains small acorn-shaped microfossils that are identified here as *Torispora securis* Balme (1952), a species first described from the Big Vein seam, Somerset, England. Horst (1957) found similar microfossils in macerations of coals from the Lugau-Oelsnitz coal field of Saxony, but he referred to them as *Bestandteile* or *Wandzellen* of a microsporangium that he found in thin sections. Horst erected the genus *Bicoloria* for the sporangium.

THE SPORANGIUM

Compact colonies of *Torispora* specimens can be picked off bedding planes or extracted by maceration with KOH. If the term sporangium is synonymous with spore case, that is, an enclosing vessel, then the spore masses in question are not true sporangia. If, on the other hand, the word sporangium is simply interpreted to mean a mass of congenetic spores, then the use of the term sporangium can be justifiably applied to these club-shaped, compact spore masses. For convenience they are called sporangia in this report. Plate 1 shows sporangia in thin section. Many sporangia are found in clusters (pl. 2, figs. 8, 9). Cell-derived vitrinite, bound by a thin exinite layer, can be seen curving around some of the clusters (pl. 1, fig. 3). This relationship leads to the assumption that the entire cluster of sporangia may have been enclosed by a wall of tissue and that the sporangial cluster represents a synangium.

Individual sporangia, as well as clusters of sporangia, have been extracted from the coal (pl. 2). Clusters can be disaggregated with a sharply pointed needle. As the individual sporangia are drop-shaped and are attached to each other at their pointed ends, the sporangia are assumed to have been pendant (pl. 2, fig. 9). No central pillar or other structure that could serve as support or means of mutual attachment of the sporangia has been observed. The individual sporangia range from 500 to 1,500 microns in length and measure from 150 to 500 microns in width.

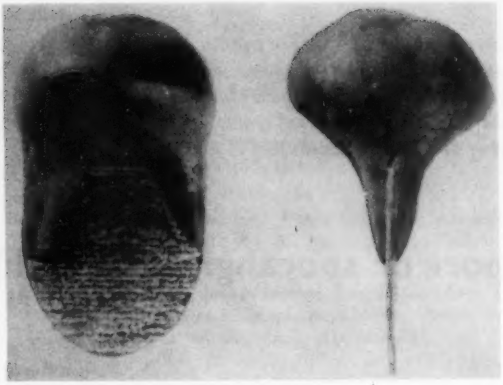
The outer layer of the sporangium is composed of *Torispora* (pl. 1, figs. 6–8), and for that reason Horst (1957) interpreted Balme's *Torispora securis* as the wall cells of the sporangium that he named *Bicoloria gothanii*.

Whether *Torispora* is a spore or a wall cell may never be proved, as function cannot be demonstrated in fossil material. Normally a sporangial wall is considered to be tissue whose cells must be contiguous and alike in origin and function. The outer layer of *Bicoloria gothanii* can hardly be described as tissue, as it is made up of individual entities (*Torispora*) that are not cemented together.

Horst (1957) suggests that the generic name *Torispora* might be retained if it can be proved that *Torispora* is a spore. Balme (1959) cites article 62 of the International Code of Botanical Nomenclature (Lanjouw and others, 1956) in defending the retention of the name *Torispora*. This article prevents rejection of a name or epithet because of inappropriateness or loss of original meaning. Balme argues further that the first published name has priority and that nomenclatural confusion can be avoided by retaining a name that may have been erroneously applied rather than discarding names with every new interpretation.

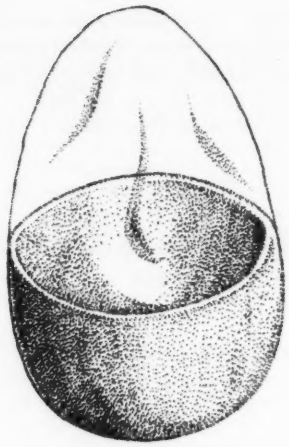
Most of Horst's description of the sporangium *Bicoloria gothanii* is actually based on isolated *Wandzellen*, that is, *Torispora* specimens. When he says that *Bestandteile* of a microsporangium can be used as guide fossils to identify the Lugau-Oelsnitz coal seams, he means *Torispora* specimens found in macerations and not the sporangia.

*Published with permission of the State Geologist, Indiana Department of Conservation, Geological Survey.



TEXT-FIGURE 1

Photograph of *Torispora* model as conceived by Horst (1957).



TEXT-FIGURE 2

Diagrammatic drawing of typical *Torispora* specimen.

THE SPORES

The resistance of *Torispora* specimens to maceration with strong oxidizing agents and their yellow color in thin section indicate that these bodies are composed of exinelike material. Although the *Torispora* layer may have had a protective function, the individual specimens certainly resemble spore exines in composition. Moreover, they have developed from the small bodies that make up the interior of the sporangium. Horst (1957) called the thin-walled, inner bodies *Mikrosporen* and pointed out that they correspond to the membraneous portions of the *Wandzellen*. Gradations between fully developed *Torispora*, that is, bodies possessing pronounced hemispherical thickenings, and the membranous, uniformly thin-coated spores of the interior of the sporangium can be observed. Figures 1 to 4 of plate 3 show small clumps of spores obtained by disaggregating a sporangium. Several developmental stages of the thickening are in evidence. Balme (1952) hinted at this derivation with the illustration of an "adherent mass of immature spores" whose individual entities show thickenings, but not the fully developed opaque cups characteristic of *Torispora*. We believe that the exine of *Torispora* thickened in a manner similar to cuticularization. Fatty acids presumably migrated to the outer, exposed parts of the spore exines where they condensed and oxidized. The "cup" or hemispherical thickening of *Torispora* thus represents the part of the exine that was exposed to oxidation on the periphery of the sporangium. Figures 11 to 16 of plate 3 show some fully developed *Torispora* specimens obtained by disaggregating a sporangium. Balme (1952) described *Torispora securis* as an elliptical, distinctly monolete spore with one extremity thickened and "expanded into a crescentic or rectangular projection darker in colour than the remainder of the spore coat." Horst (1957) disagreed with Balme's contention that *Torispora securis* is monolete, arguing that there is no tetrad mark and that chance folding of the thin membraneous part caused simulated monolete or triradiate patterns. Our studies show that folding of the "neck" can produce linear folds that look like monolete or triradiate scars (pl. 3, figs. 3, 11, 12, 15). Similarly, folding caused simulated monolete and triradiate markings on the membraneous spores of the interior of the sporangium. Figures 6 and 7 of plate 3 show that folding can simulate triangular shapes and trilete scars that would make these bodies assignable to *Leiotriletes*, if found isolated in macerations. The specimen shown as figure 5, if found isolated, would be classified as one of the bilateral, monolete spore types, such as *Laevigatosporites* or *Punctatosporites*. Dybova and Jachowicz (1957), in describing spores from the Zwickau boghead coal of Saxony, erected three new species of *Torispora* on the basis of shape and size of the cup. As the cups can vary greatly

PLATE 1

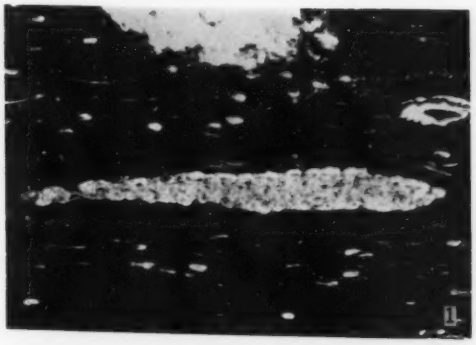
1–2 Single sporangia (*Bicoloria*) in thin section; ca. × 100.

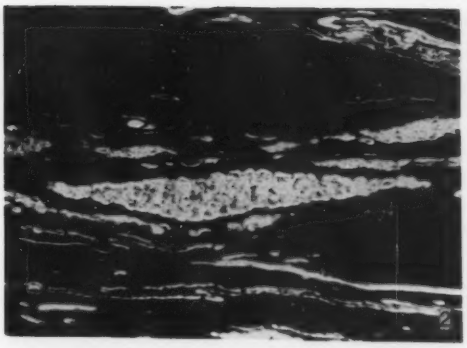
3–4 Clusters of sporangia in thin section; ca. × 100.

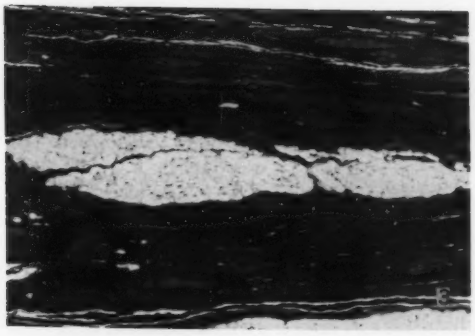
5 Tip of a single sporangium showing the conforming coaly matrix; ca. × 300.

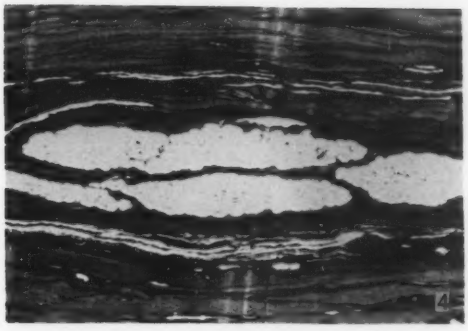
6 Tip of a sporangium showing layer of *Torispora* enclosing compacted spores; ca. × 300.

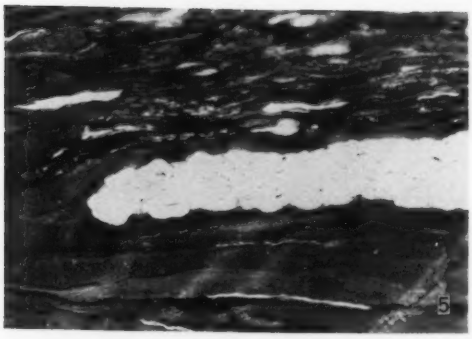
7–8 Tips of sporangia showing arrangement of *Torispora*; ca. × 500.

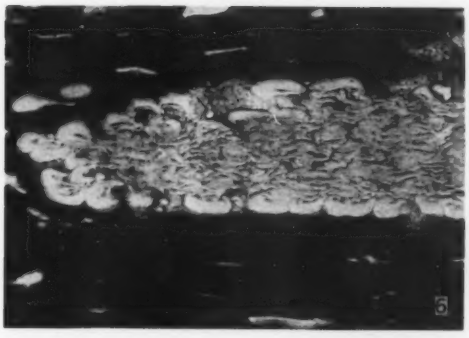

1


2


3


4


5


6

7

8

in shape, owing to positioning within the compacted layering of the sporangium, we doubt that speciation is justified on that basis.

Horst's model (text-fig. 1) is not considered to be typical of *Torispora*. The membraneous neck, which Horst shows as being long and flat, may have many shapes. Moreover, the neck is continuous with the wall of the cup, not inserted or embedded in the cup as Horst's model indicates. A typical *Torispora* specimen with fully expanded neck and unaltered cup would look like an acorn. The cup, however, is continous with the wall of the neck rather than enclosing it (text-fig. 2).

Paleobotanical nomenclature deals with form or organ genera. Parallel systems and multiplicity of names are therefore accepted necessary evils. The genus *Torispora*, circumscribing isolated sporelike bodies, is validly established, just as there can be no objection to a new microsporangium genus being described as *Bicoloria* by Horst. We recommend that the name *Bicoloria* be restricted to Horst's description of the sporangium and that *Torispora* be retained as a spore genus.

GEOLOGIC RANGE

Balme (1952) did not find *Torispora securis* below Westphalian C in England, and Dybova and Jachowicz (1957) found the genus restricted to the Libiaz beds (Westphalian D) in Poland. Potonie and Kremp (1956) restricted *Torispora* to the Westphalian C and D in the Ruhr Basin, and Horst (1947) even termed it a guide fossil of the Westphalian D of Saxony.

The Indiana paper coal is equatable with one of the Upper Block coal zones (UBb) on the basis of spore assemblages, and is thus late Pottsville in age. The upper Pottsville strata of Indiana have been correlated with the Westphalian B of Europe (Moore and others, 1944).

If dispersed spores are treated purely on a morphographic basis then age and / or stratigraphic considerations are invalid criteria for taxonomic differentiation. Rather than assuming that the Indiana *Torispora* specimens are different from *T. securis* because they are older, we choose to extend the stratigraphic range downward to include the American equivalent of Westphalian B of Europe.

BIBLIOGRAPHY

BALME, B. E.
1952 – *On some spore specimens from British Upper Carboniferous coals*. Geol. Mag., vol. 89, no. 3, pp. 175–184, 3 figs.
1959 – *Bemerkungen über die Art "Bicoloria gothanii Horst."* Geologie, vol. 8, no. 1, p. 103.

DYBOVA, SONA, and JACHOWICZ, ALEXANDER
1957 – *Das Alter des Zwickau-Lugauer Bogheads auf Grund der palynologischen Analyse*. Geologie, vol. 6, pp. 674–697, 6 pls.

HORST, ULRICH
1957 – *Ein Leitfossil der Lugau-Oelsnitzer Steinkohlenfloeze*. Geologie, vol. 6, pp. 698–720, 8 pls., 1 fig.

LANJOUW, J., and others
1956 – *International code of botanical nomenclature*. Utrecht: Kemink en Zoon, pp. 7–56.

MOORE, R. C., and others
1944 – *Correlation of Pennsylvanian formations of North America*. Geol. Soc. Amer., Bull., vol. 55, pp. 657–706.

NEAVEL, RICHARD C., and GUENNEL, G. K.
1958 – *Occurrence of paper coal in Indiana*. Geol. Soc. Amer., Bull., vol. 69, no. 12, pt. 2, pp. 1622–1623.

POTONIE, ROBERT, and KREMP, GERHARD
1956 – *Die Sporae dispersae des Ruhrkarbons*, Teil II. Palaeontographica, vol. 99, Abt. B, pp. 85–191, pls. 7–22, figs. 38–88.

PLATE 2

1–7 Sporangia (*Bicoloria*) isolated and photographed under reflected light; ca. × 50.

8 Cluster of sporangia photographed under reflected light; ca. × 50.

9 Cluster of sporangia showing attachment tissue; photographed under reflected light; ca. × 50.

10 Cluster of sporangia photographed under transmitted light; bleached with **clorox**; ca. × 50.

11 Part of bleached sporangium showing arrangement of spores; photographed under transmitted light; ca. × 200.

12–13 Bleached sporangia photographed under transmitted light; ca. × 50.

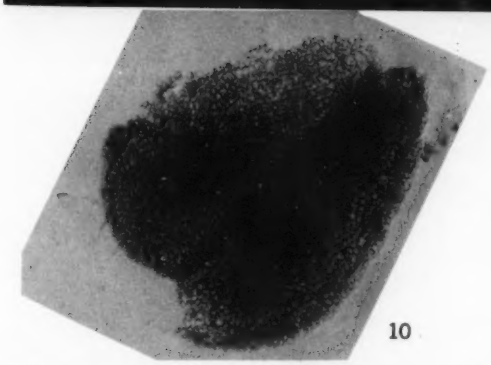
PLATE 3

All figures ca. × 1,000

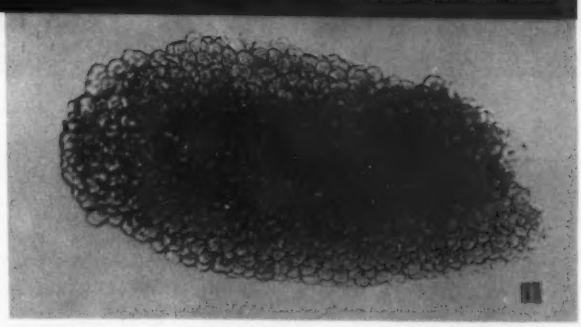
1–4 Clumps of spores from disaggregated sporangium; partially developed *Torispora* specimens are shown in close association with nonthickened spores.

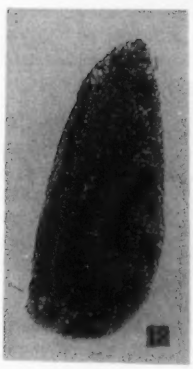
5–10 Membraneous spores from disaggregated sporangium; figure 5 shows linear fold that simulates monolete scar, and figures 6 and 7 show triangular spores that display simulated trilete scars.

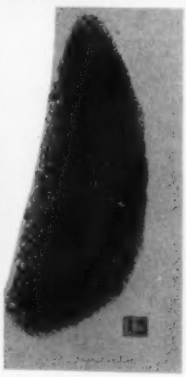
11–16 *Torispora* specimens obtained by disaggregating a sporangium.

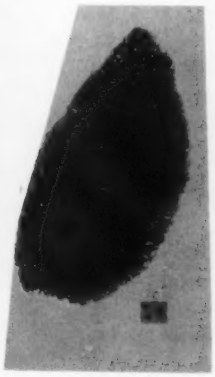


10

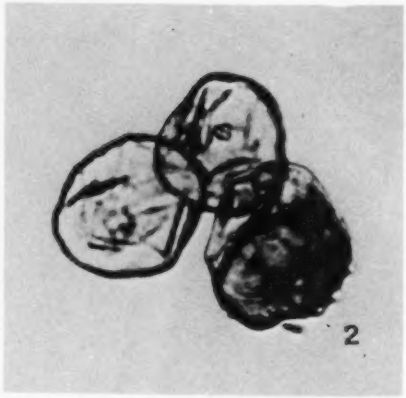


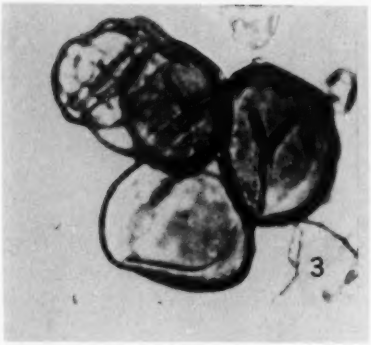




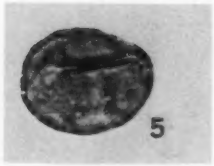


1


2

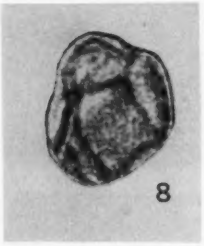

3

4


5

6

7


8

9

10

11

12

13

14

15

16

ABSTRACT

Three hundred and sixty-one published articles and 42 theses and dissertations that concern or mention conodonts are listed. Four hundred and ninety new forms including 41 new genera and 421 new species are described in the published articles. Conodonts are now known to range from Late Cambrian through Late Triassic time and possibly into Late Cretaceous time. They have been reported found in 31 countries.

Bibliography and index of conodonts, 1949—1958*

SIDNEY R. ASH
U. S. Geological Survey
Albuquerque, New Mexico

INTRODUCTION

Nearly 1100 articles concerning or mentioning conodonts are known to have been published during the 106 years following 1853 when Pander discovered these interesting microfossils, and until recently only a few publications appeared annually (text-fig. 1). Two hundred and five articles were published during the 75 years between 1854 and 1930, an average of about 4 per year although none were published in some years. Four hundred and three articles were published in the 1930's and 1940's, an average of about 20 per year. Approximately 400 publications appeared during the 1950's, an average of about 40 articles per year.

Practically all the work done on conodonts through July 31, 1949, was summarized by Robert O. Fay in his Catalogue of Conodonts (1952). The relatively large amount of work done on conodonts since Fay concluded his compilation indicates that an occasional bibliography and index is needed to supplement the Catalogue. The present paper covers the period from July 31, 1949, to December 31, 1958, and consists of a bibliography, an index of new forms, an index of conodont-bearing formations, and a table which shows the known geological and geographical distribution of conodont-bearing formations.

A biennial supplement for 1959–60 is in preparation. It will include articles published during 1959–60 and those omitted from this paper which are brought to the writer's attention. In order to make the supplement as complete as possible, authors are requested either to advise the compiler of articles which should be indexed or to send him reprints of their publications.

It is a pleasure to acknowledge the generous assistance given me by the following: Mr. Robert O. Fay, who not only encouraged me to prepare this paper but advised me, as well, on its preparation and brought a number of articles to my attention; Dr. Roger Y. Anderson, Dr. Samuel P. Ellison, Jr., Dr. R. L. Ethington, Dr. Brian F. Glenister, Dr. W. H. Hass, Dr. Maurits Lindström, Mrs. Elizabeth Kuntz, Dr. Carl A. Lamay Dr. Maurice G. Mehl, Dr. Klaus J. Müller, Mr. Dwayne D. Stone, and Dr. Walter C. Sweet, who provided me with information and help of various types; and Dr. J. Paul Fitzsimmons, who translated portions of the articles written in the German and Russian languages.

*Publication authorized by the Director, U. S. Geological Survey.

BIBLIOGRAPHY

In the first part of the following bibliography are listed the 344 articles known to have been published between July 31, 1949, and December 31, 1958, and 17 articles published prior to July 31, 1949, that were not included in the Catalogue of Conodonts (Fay, 1952). In the second part 42 theses and dissertations that were prepared between 1940 and 1958 are listed.

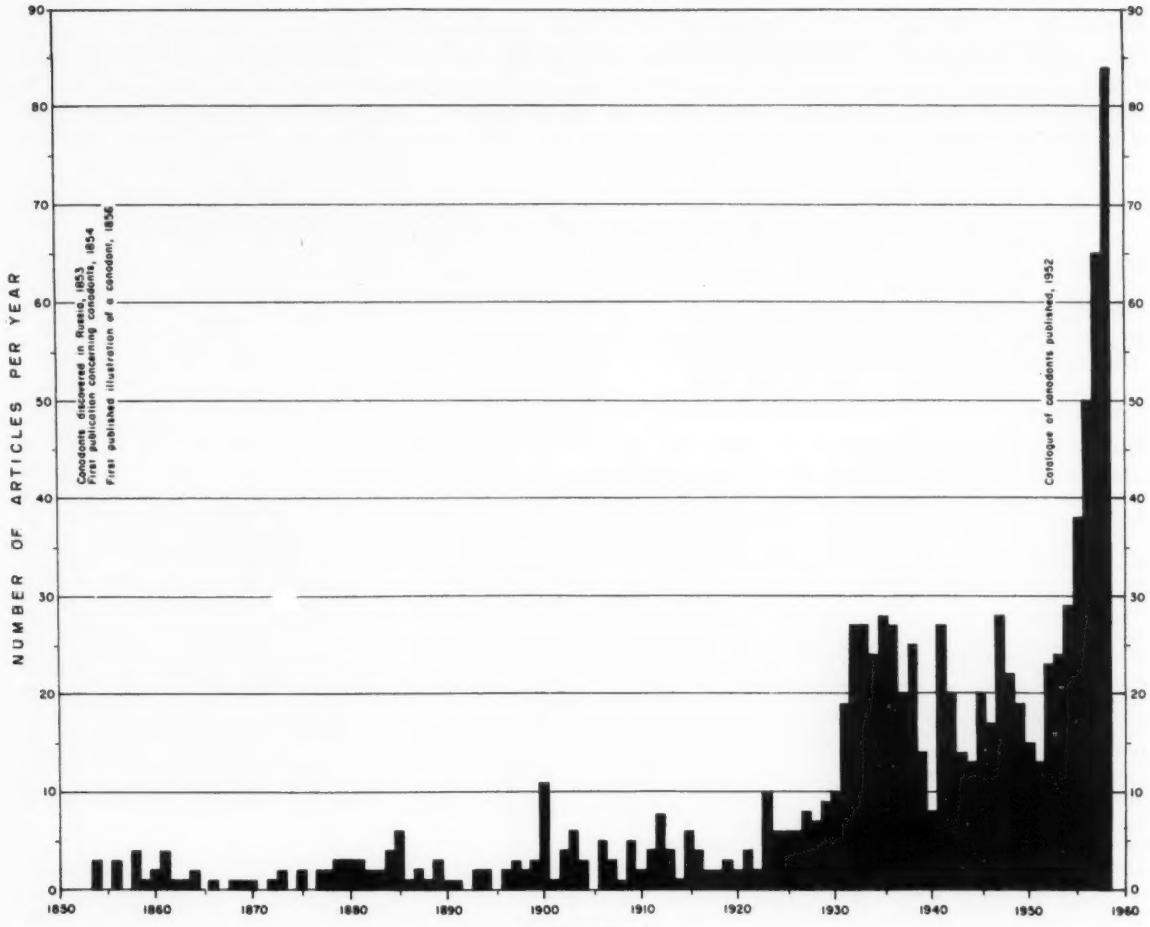
PUBLISHED ARTICLES

An asterisk* marks those articles in which new forms of conodonts are proposed and those which are of taxonomic interest for other reasons.

AMSDEN, T. W.
1957*a* *Catalog of fossils from the Middle and Upper Ordovician of Oklahoma.* Oklahoma, Geol. Survey, Circ. 43, 41 pp., (conodonts, pp. 9–12, 25–27, 35).
1957*b* *Stratigraphy and paleontology of the Hunton group in the Arbuckle Mountain region: part I — introduction to stratigraphy.* Oklahoma, Geol. Survey, Circ. 44, 57 pp., 3 pls., 6 text-figs., (conodonts, pp. 17, 19, 20, 21, 23, 24, 28).

ARANT, W. H.
1958 – *King Creek marl member of the Chappel formation.* In: FILLMAN, L. (Chm.), *Lexicon of pre-Pennsylvanian stratigraphic names of west Texas and southeast New Mexico.* Midland; West Texas Geol. Soc., p. 73.

BACHMANN, M.
1954 – *Das Ordovizium in der Gegend von Schleiz (Ostthüringen).* Neues Jahrb. Geol. Pal., Monatshefte, Jahrg. 1954, pp. 260–267, 4 text-figs., 1 table, (conodonts, pp. 260, 264–267). (Bib. Geol. Excl. North Amer., 1957, vol. 20 (1955), p. 23.)



TEXT-FIGURE 1

Number of articles concerning or mentioning conodonts which are known to have been published each year since 1854. Data compiled from the Catalogue of Conodonts (Fay, 1952) and this paper.

BARNARD, T.

1953 – *News: Great Britain.* The Micropaleontologist, vol. 7, no. 3, pp. 6–9, (conodonts, p. 7).

1956 – *News reports: Great Britain.* Micropaleontology, vol. 2, no. 3, pp. 307–308, (conodonts, p. 308).

1957 – *News reports: Great Britain.* Micropaleontology, vol. 3, no. 4, pp. 415–416, (conodonts, p. 416).

BARNES, V. E., CLOUD, P. E., JR., and DUNCAN, H.

1953 – *Upper Ordovician of Texas.* Amer. Assoc. Petr. Geol., Bull., vol. 37, no. 5, pp. 1030–1043, 3 text-figs., (conodonts, pp. 1033, 1036).

BASS, N. W., and NORTHROP, S. A.

1953 – *Dotsero and Manitou formations, White River plateau, Colorado, with special reference to Clinetop algal limestone member of Dotsero formation.* Amer. Assoc. Petr. Geol., Bull., vol. 37, no. 5, pp. 889–912, 9 text-figs., (conodonts, pp. 889, 905, 906, 908–911). (Geol. Abstr., 1953, vol. 1, nos. 1–2, p. 6.)

1955 – *Lower Paleozoic rocks of the White River uplift, Colorado.* In: RITZMA, H. R. and ORIEL, S. S., Intermountain Association of Petroleum Geologists, Guidebook, 6th Annual Field Conference, Geology of northwest Colorado, pp. 3–9, 2 text-figs., (conodonts, p. 6).

BECKMANN, H.

1949 – *Conodonten aus dem Iberger Kalk (Ober-Devon) des Bergischen Landes und ihr Feinbau.* Senckenbergiana Lethaea, vol. 30, nos. 1–3, pp. 153–168, pls. 1–4. (Biol. Abstr., 1950, vol. 24, p. 3586; Zentr. Geol. Pal., 1951, pt. 2, Jahrg. 1950, p. 195; *ibid.*, 1952, Jahrg. 1951, p. 58; Bib. Geol. Excl. North Amer., 1952, vol. 16 (1951), p. 19.)

1952*a* *Zur Anwendung von Essigsäure in der Mikropaläontologie.* Pal. Zeitschr., vol. 26, nos. 1–2, pp. 138–139. (Biol. Abstr., 1953, vol. 27, p. 766; Bib. Geol. Excl. North Amer., 1954, vol. 18 (1953), p. 28.)

1952*b* *The use of acetic acids in micropaleontology.* The Micropaleontologist, vol. 6, no. 3, p. 39.

1953 – *Die Bedeutung von Conodonten für die Stratigraphie des Devons in der Lahn- und Dillmulde.* Hessen, Landesamt Bodenf., Notizbl., vol. 81, pp. 63–68, pl. 2. (Biol. Abstr., 1954, vol. 28, p. 2466; Bib. Geol. Excl. North Amer., 1955, vol. 19 (1954), p. 33; Zentr. Geol. Pal., 1958, pt. 2, Jahrg. 1957, p. 525.

1958 – *Arbeitstechniken und Erfahrungen der Mikropaläontologie in Paläozoikum.* In: FREUND, H., *Handbuch der Mikroskopie in der Technik, vol. 2, part 3.* Frankfurt; Umschau Verlag, pp. 147–165, 3 text-figs., 2 pls.

BENDER, H.

1958 – *Ein Querprofil durch den Westteil der Hörre und ihre "Phyllite" (Ulmbachtal; Rheinisches Schiefergebirge).* Hessen, Landesamt Bodenf., Notizbal., vol. 87, pp. 78–88, 2 text-figs.

BENSON, R. H. and COLLINSON, C.

1958 – *Three ostracode faunas from Lower and Middle Mississippian strata in southern Illinois.* Illinois, Geol. Survey, Circ. 255, 26 pp., 14 text-figs., 4 pls., (conodonts, pp. 2–5). (Geol. Abstr., vol. 6, no. 4, p. 142.)

BERDAN, J. M.

1953 – *Devonian ostracode fauna from Nevada.* Geol. Soc. Amer., Bull., vol. 64, no. 12, pt. 2, p. 1394 (abstract).

BISCHOFF, G.

1955 – *Das Profil Amonau bei Marburg und das Alter der "Buchenauer Schichten" auf Grund von Conodonten.* Hessen, Landesamt Bodenf., Notizbl., vol. 83, pp. 126–131. (Micropaleontology, 1957, vol. 3, no. 4, p. 399; Zentr. Geol. Pal., 1958, pt. 2, Jahrg. 1957, pp. 525–526.)

*1956 – *Oberdevonische Conodonten (to I δ) aus dem Rheinischen Schiefergebirge.* Hessen, Landesamt Bodenf., Notizbl., vol. 84, pp. 115–137, pls. 8–10. (Micropaleontology, 1957, vol. 3, no. 4, p. 399; Zentr. Geol. Pal., 1958, pt. 2, Jahrg. 1957, p. 525.)

*1957 – *Die Conodonten-Stratigraphie des rheno herzynischen Unterkarbons mit Berücksichtigung der Wocklumeria-Stufe und der Devon/Karbon-Grenze.* Hessen, Landesamt Bodenf., Abh. no. 19, 64 pp., 6 pls., 1 text-fig., 2 tables. (Zentr. Geol. Pal., 1958, pt. 2, Jahrg. 1957, p. 527; Bib. Geol. Excl. North Amer., 1958, vol. 22 (1957), p. 54; Micropaleontology, 1958, vol. 4, no. 4 p. 431.)

BISCHOFF, G., and SANNEMANN, D.

*1958 – *Unterdevonische Conodonten aus dem Frankenwald.* Hessen, Landesamt Bodenf., Notizbl., vol. 86, pp. 87–110, pls. 12–15.

BISCHOFF, G., and STOPPEL, D.

1957 – *Zum Alter des Wollenberg-Kellerwald-Quarzits (Rheinisches Schiefergebirge).* Neues Jahrb. Geol. Pal., Monatshefte, Jahrg. 1957, pp. 14–24, 4 text-figs. (Zentr. Geol. Pal., 1958, pt. 2, Jahrg. 1957, pp. 527–528; Bib. Geol. Excl. North Amer., 1958, vol. 22 (1957), p. 54; Micropaleontology, 1958, vol. 4, no. 4, p. 431.)

BISCHOFF, G. and ZIEGLER, W.

*1956 – *Das Alter der "Urfer Schichten" im Marburger Hinterland nach Conodonten.* Hessen, Landesamt Bodenf., Notizbl., vol. 84, pp. 138–169, pls. 11–14, 1 table. (Micropaleontology, 1957, vol. 3, no. 4, p. 399; Zentr. Geol. Pal., 1958, pt. 2, Jahrg. 1957, p. 528.)

*1957 – *Die Conodontenchronologie des Mitteldevons und des tiefsten Oberdevons.* Hessen, Landesamt Bodenf., Abh., no. 22, 136 pp., 21 pls., 16 text-figs., 5 tables. (Micropaleontology, 1958, vol. 4, no. 4, p. 432.)

BLACKSTONE, D. L., JR., and MCGREW, P. O.

1954*a* *New occurrence of Devonian rocks in north-central Wyoming.* In: RICHARDS, P. W. (Ed.), Billings Geological Society, Guidebook, 5th Annual Field Conference, Pryor mountains, northern Bighorn Basin, Montana, pp. 38–43, 3 pls.

1954*b* *New occurrences of Devonian rocks in north-central Wyoming.* Geol. Soc. Amer., Bull., vol. 65, no. 12, pt. 2, p. 1371 (abstract).

BOLTOVSKOY, E.

1955 – *News reports: Argentina.* Micropaleontology, vol. 1, no. 4, pp. 384–386, (conodonts, p. 385).

BOUCOT, A. J.

1958 – *Age of the Bainbridge limestone.* Jour. Pal., vol. 32, no. 5, pp. 1029–1030.

BOWEN, R. N. C.

1956 – *Some curious fossil groups.* Sci. Progr., vol. 44, no. 174, pp. 237–248, (conodonts, pp. 241–245, 247).

BRANSON, C. C.

1957*a* *Oldest conodonts found in Oklahoma.* Oklahoma, Geol. Survey, Geol. Notes, vol. 17, no. 2, p. 21.

1957*b* *Ordovician conodonts.* Oklahoma, Geol. Survey, Geol. Notes, vol. 17, no. 9, p. 87.

BRANSON, E. B., and MEHL, M. G.

1952 – *Zonal correlations by means of conodonts.* Intern. Geol. Congr., 18th, Great Britain, Rept., pt. 10, p. 33 (abstract, with discussion). (Biol. Abstr., 1953, vol. 27, p. 3171.)

BRANSON, E. B., MEHL, M. G., and BRANSON, C. C.

*1951 – *Richmond conodonts of Kentucky and Indiana.* Jour. Pal., vol. 25, no. 1, pp. 1–17, pls. 1–4, 2 text-figs., 1 table. (Biol. Abstr., 1951, vol. 25, p. 2868; Zentr. Geol. Pal., 1952, pt. 2, Jahrg. 1951, pp. 442–443.)

BROTZEN, F.

1953 – *News: Scandinavia-Sweden.* The Micropaleontologist, vol. 7, no. 2, pp. 30–31.

BUCHER, W. H.

1929 – *Tetractinellid sponge in Sunbury shales.* Pan-Amer. Geol., vol. 51, no. 3, p. 230 (abstract).

CHRONIC, J.

1957 – *No. 8: McCoy-Burns measured section.* In: MCKEE, E. D. (Ed.), *Colorado measured sections, a symposium.* Denver, Rocky Mt. Assoc. Geol., pp. 39–45, (conodonts, measured section strip no. 8).

1958 – *Pennsylvanian paleontology in Colorado.* In: *Symposium on Pennsylvanian rocks of Colorado and adjacent areas.* Denver, Rocky Mt. Assoc. Geol., (conodonts, p. 13, fig. 2).

CLARK, D. L.

1957 – *Marine Triassic stratigraphy in eastern Great Basin.* Amer. Assoc. Petr. Geol., Bull., vol. 41, no. 10, pp. 2192–2222, 10 text-figs., (conodonts, pp. 2192, 2199, 2201, 2202, 2204, 2205, 2207, 2210). (Geol. Abstr., vol. 5, no. 4, p. 5.)

CLARK, L. M.
1954 – *Geology of Rocky Mountain Front Ranges near Bow River, Alberta, (Revised).* In: CLARK, L. M. (Ed.), *Western Canada sedimentary basin, Symposium.* Tulsa; Amer. Assoc. Petr. Geol., pp. 29–46, (conodonts, p. 37). Originally published in 1949.

CLARKE, J. M.
1891 – *The fauna with Goniatites intumescens Beyrich, in western New York.* Amer. Geol., vol. 8, no. 2, pp. 86–105, (conodonts, pp. 88–89, 93).

CLOUD, P. E., JR., BARNES, V. E., and HASS, W. H.
1957 – *Devonian-Mississippian transition in central Texas.* Geol. Soc. Amer., Bull., vol. 68, no. 7, pp. 807–816, 1 text-fig., 5 pls.

COLLINSON, C. W.
1956 – *Guide for beginning fossil hunters.* Illinois, Geol. Survey, Educational Series 4, 36 pp., 10 pls., 20 text-figs. (conodonts, pp. 31–33, pl. 10, text-fig. 19).

COLLINSON, C. W., and SCOTT, A. J.
1958*a* *Chitinozoan faunule of the Devonian Cedar Valley formation.* Illinois, Geol. Survey, Circ. 247, 34 pp., 3 pls., 13 text-figs., (conodonts, pp. 6–11). (Geol. Abstr., vol. 6, no. 1, p. 130.)
1958*b* *Age of the Springville shale (Mississippian) of southern Illinois.* Illinois, Geol. Survey, Circ. 254, 12 pp., 6 text-figs., 1 table. (Geol. Abstr., vol. 6, no. 3, p. 100.)

COLTON, G. W.
1956 – *Bedrock geology of the Hamburg quadrangle, New York.* U. S. Geol. Survey, Geol. Quadrangle Map, GQ97.

COSSMAN, M.
1909 – *Rectifications de Nomenclature.* Revue critique Paléozoologie, vol. 13, no. 1, pp. 67–68, (conodonts, p. 68).

CRAIG, G. Y.
1952 – *A comparative study of the ecology and palaeoecology of Lingula.* Geol. Soc. Edinburgh, Trans., vol. 15, pp. 110–120, 2 text-figs., pl. 4, (conodonts, p. 116). (Bib. Geol. Excl. North Amer., 1953, vol. 17–1952, p. 90.)
1954 – *The paleoecology of the Top Hosie shale (Lower Carboniferous) at a locality near Kilsyth.* Geol. Soc. London, Quart. Jour., vol. 110, pp. 103–119, 3 text-figs., (conodonts, pp. 105, 112, 113) (with discussion). (Bib. Geol. Excl. North Amer., 1955, vol. 19 – 1954, p. 100.)

CRESPIN, I.
1956 – *Micropaleontological investigations in the Bureau of Mineral Resources, Geology and Geophysics, 1927–1952.* Australia, Bur. Min. Res., Geol. and Geophysics, Rept. no. 20, 77 pp., (conodonts, pp. 72, 74).
1958 – *News reports: Australia.* Micropaleontology, vol. 4, no. 1, p. 116.

CURRIE, E. D., DUNCAN, C., and MUIR-WOOD, H. M.
1937 – *The fauna of Skipsey's Marine Band.* Geol. Soc. Glasgow, Trans., vol. 19, no. 17, pp. 413–451, (conodonts, pp. 415, 431–434, pl. 3, figs. 1–7, table 1).

CUVILLIER, J.
1957 – *News reports: France.* Micropaleontology, vol. 3, no. 4, pp. 411–415, (conodonts, p. 411).
1958 – *News reports: France.* Micropaleontology, vol. 4, no. 4, pp. 442–447, (conodonts, pp. 442, 445).

DEMANET, F.
1949 – *Contribution a l'etude de la microfaune marine du Westphalien de la Campine.* Inst. Roy. Sci. Nat. Belgique (Koninklijk Belgisch Inst. Naturw.), Bull., vol. 25, no. 37, 16 pp., 2 pls., (conodonts, pp. 1, 2, 12, 13–16, pl. 2, fig. 6). (Zentr. Geol. Pal., Jahrg. 1950, pt. 2, pp. 197–198; Biol. Abstr., 1951, vol. 25, p. 1728.)

DENISON, R. H.
1956 – *A review of the habitat of the earliest vertebrates.* Fieldiana, Geol., vol. 11, no. 8, pp. 357–457, (conodonts, pp. 362, 368, 370, 372, 388, 423). (Biol. Abstr., vol. 31, p. 335.)

DEWITT, W., JR.
1956 – *Bedrock geology of the Eden quadrangle, New York.* U. S. Geol. Survey, Geol. Quadrangle Map, GQ 96.

DEWITT, W., JR., and COLTON, G. W.
1953 – *Bedrock geology of the Silver Creek quadrangle, New York.* U. S. Geol. Survey, Geol. Quadrangle Map, GQ 30.

DIEBEL, K.
1956*a* *Über Trias-Conodonten.* Geologie, vol. 5, no. 1, pp. 9–12 (abstract). (Pal. Zeitschr., 1956, vol. 30, p. 19; Micropaleontology, 1957, vol. 3, no. 4, p. 400; Zentr. Geol. Pal., 1958, pt. 2, Jahrg. 1957, no. 5, p. 529; Bib. Geol. Excl. North Amer., 1958, vol. 21 (1956), p. 142.)
*1956*b* *Conodonten in der Oberkreide von Kamerun.* Geologie, vol. 5, nos. 4–5, pp. 424–450, 6 pls., 2 text-figs. (Zentr. Geol. Pal., 1957, pt. 2, Jahrg. 1956, no. 5, p. 705; Micropaleontology, 1957, vol. 3, no. 4, p. 400; Zentr. Geol. Pal., 1958, pt. 2, Jahrg. 1957, no. 5, pp. 529–530.)
1957 – *Jüngste mesozoische Conodonten.* Pal. Zeitschr., vol. 31, pp. 6–7 (abstract). (Bib. Geol. Excl. North Amer., 1958, vol. 22 (1957), p. 130; Micropaleontology, 1958, vol. 4, no. 4, p. 432.)

DINELEY, D. L., and RHODES, F. H. T.
1956 – *Conodont horizons in the west and south-west of England.* Geol. Mag., vol. 93, no. 3, pp. 242–248, 18 text-figs. (Zentr. Geol. Pal., 1958, pt. 2, Jahrg. 1957, no. 5, p. 530; Bib. Geol. Excl. North Amer., 1958, vol. 21 (1956), p. 143.)

DOUGLASS, R. C.
1958 – *News reports: United States – East Coast.* Micropaleontology, vol. 4, no. 1, pp. 125–128, (conodonts, p. 126).

DOWNS, H. R. and YOUNGQUIST, W. L.
*1950 – *Conodonts from the Cedar Valley limestone of Iowa.* Jour. Pal., vol. 24, no. 6, pp. 667–672, pl. 87. (Biol. Abstr., 1951, vol. 25, p. 1728; Bib. North Amer. Geol. (1950), 1952, p. 81.)

DUNHAM, K. C., and STUBBLEFIELD, C. J.
1945 – *The stratigraphy, structure and mineralization of the Greenhow mining area, Yorkshire.* Geol. Soc. London, Quart. Jour., vol. 100, pp. 209–268, (conodonts, p. 240).

EARP, J. R. and MAGRAW, D.
1955 – *Tonge's Marine Band in Lancashire.* Great Britain, Geol. Survey, Bull. 9, pt. 2, pp. 22–32, 2 text-figs., (conodonts, p. 31). (Bib. Geol. Excl. North Amer., 1957, vol. 20 (1955), p. 140.)

ECHOLS, D. J.
1955 – *News reports: Mid Continent, United States.* Micropaleontology, vol. 1, no. 1, pp. 98–100, (conodonts, p. 99).
1956 – *News reports: United States – Mid Continent.* Micropaleontology, vol. 2, no. 1, pp. 101–102, (conodonts, p. 101).
1957 – *News reports: United States – Mid Continent.* Micropaleontology, vol. 3, no. 1, pp. 94–97, (conodonts, pp. 95–96).
1958 – *News reports: United States – Mid Continent Region.* Micropaleontology, vol. 4, no. 2, pp. 224–227, (conodonts, pp. 225–227).

EDEN, R. A.
1954 – *The Coal Measures of the Anthraconaia lenisulcata zone in the East Midlands coalfield.* Great Britain, Geol. Survey, Bull. 5, pt. 3, pp. 81–106, pl. 2, 2 text-figs., (conodonts, pp. 82, 84, 94, 101, 105, 106). (Bib. Geol. Excl. North Amer., 1955, vol. 19–1954, p. 127.)

EDWARDS, W.
1954 – *The Yorkshire-Nottinghamshire coalfield.* In: TRUEMAN, A. (Ed.), *The coalfields of Great Britain.* London; Edward Arnold, Ltd., (conodonts, p. 187).

ELIAS, M. K.
1954 – *Late Mississippian – early Pennsylvanian of southern mid-continent.* Jour. Sed. Petr., vol. 24, no. 2, p. 142 (abstract). Also in Jour. Pal., vol. 28, no. 4, p. 514.
*1956*a* *Upper Mississippian and Lower Pennsylvanian formations of south-central Oklahoma.* In: *Petroleum geology of southern Oklahoma, a symposium sponsored by the Ardmore Geological Society. vol. 1.* Tulsa, Amer. Assoc. Petr. Geol., pp. 56–134, pls. 1–6, text-figs. 1–2, tables 1–6. (Zentr. Geol. Pal., 1958, pt. 2, Jahrg. 1957, no. 5, p. 531.)
1956*b* *Upper Mississippian and Lower Pennsylvanian formations of southern Oklahoma (corrections).* Amer. Assoc. Petr. Geol., Bull., vol. 40, no. 10, p. 2513.

ELLISON, S. P., JR.
1949 – *Subsurface Woodford black shale of west Texas and southeast New Mexico.* Geol. Soc. Amer., Bull., vol. 60, no. 12, p. 1885 (abstract).
1950 – *Subsurface Woodford black shale, west Texas and southeast New Mexico.* Texas, Univ. (Bur. Econ. Geol.), Rept. of Invest., no. 7, 20 pp., 6 text-figs., 3 pls. Reviewed in Amer. Assoc. Petr. Geol., Bull., vol. 35, no. 3, p. 627, 1951. (Bib. North Amer. Geol. (1950), 1952, p. 86.)
1957 – *Conodonts.* In: LADD, H. S. (Ed.), *Treatise on marine ecology and paleoecology.* Geol. Soc. Amer., Mem. 67, pp. 993–994. (Biol. Abstr., 1957, vol. 31, p. 3021.)

ELLISON, S. P., JR., and WYNN, W. T.
1950 – *Devonian microfossils, Andrews County, Texas.* Amer. Jour. Sci., vol. 248, no. 11, pp. 794–799, 1 pl., 2 text-figs. (Bib. North Amer. Geol. (1950), 1952, p. 86.)

ENBYSK, B. J.
1956 – *Additions to the Devonian and Carboniferous faunas of northeastern Washington.* Geol. Soc. Amer., Bull., vol. 67, no. 12, pt. 2, p. 1766 (abstract).

ETHINGTON, R. L., FURNISH, W. M., and MARKEWICZ, F. J.
1958 – *Ordovician conodonts in New Jersey.* Jour. Pal., vol. 32, no. 4, pp. 763–765, 1 text-fig.

FABIANI, R.
1952 – *Carbonifero.* In: *Trattato Di Geologia.* Rome, Istituto Grafico Tiberino, text-figs. 122-l, 122-m.

FALKE, H.
1957 – *Zur Geologie der Umgebung von Stromberg (Hunsrück).* Hessen, Landesamt Bodenf., Notizbl., vol. 85, pp. 75–113, 7 text-figs., pl. 5, (conodonts, pp. 87, 88, 94, 96, 112). (Micropaleontology, 1958, vol. 4, no. 4, p. 432.)

FAY, R. O.
*1952 – *Catalogue of conodonts.* Kansas, Univ., Pal. Contr., Vertebrata, art. 3, 206 pp., 109 text-figs. (Biol. Abstr., 1954, vol. 28, pt. 4, p. 2960.)
1957 – *Cretaceous conodonts from West Africa.* Oklahoma, Geol. Survey, Geol. Notes, vol. 17, no. 2, p. 10.
1958*a* *A key to conodont genera and subgenera.* Oklahoma, Geol. Survey, Geol. Notes, vol. 18, nos. 6–7, pp. 103–120, 132 text-figs.
1958*b* *A key to conodont genera and subgenera – addenda.* Oklahoma, Geol. Survey, Geol. Notes, vol. 18, no. 11, p. 178, 1 text-fig.

FENTON, C. L., and FENTON, M. A.
1958 – *The fossil book – a record of prehistoric life.* New York, Doubleday, 482 pp. (conodonts, pp. 262–263).

FIEBIG, H. H.
1955 – *Die Mikrofauna des Ruhrkarbons und ihre praktische Bedeutung für den Bergbau.* Deutschr. Geol. Ges., Zeitschr., vol. 105, Jahrg. 1953, pp. 550–551 (abstract).

FLUGEL, H., and ZIEGLER, W.
*1957 – *Die Gliederung des Oberdevons und Unterkarbons am Steinberg westlich von Graz mit Conodonten.* Mitt. des Naturw. Ver. für Steiermark, vol. 87, pp. 25–60, pls. 1–5, text-figs. 1–6.

FOWLER, A.
1955 – *The zonal sequence in the Carboniferous rocks of south-east Tyrone.* Great Britain, Geol. Survey, Bull. 8, pt. 2, pp. 38–43, 2 text-figs., 1 pl., (conodonts, p. 41). (Bib. Geol. Excl. North Amer., 1957, vol. 20 (1955), p. 169.)

FREDERICKSON, E. A., and POLLACK, J. M.
1952 – *Two trilobite genera from the Harding formation (Ordovician) of Colorado.* Jour. Pal., vol. 26, no. 4, pp. 641–644, 6 text-figs., (conodonts, p. 641).

GATCHEEL, J. H., and FITTS, L. E.
1951 – *Tulsa Geological Society field trip no. 3.* In: Tulsa Geological Society, Guidebook, 1950–1951 season. pp. 18–24, (conodonts, p. 22).

GLENISTER, A. T.
*1957 – *The conodonts of the Ordovician Maquoketa formation in Iowa.* Jour. Pal., vol. 31, no. 4, pp. 715–736, pls. 85–88, 3 text-figs. (Geol. Abstr., 1957, vol. 5, no. 3, p. 30.)

GLENISTER, B. F.
1958 – *Upper Devonian ammonoids from the Manticoceras zone, Fitzroy basin, Western Australia.* Jour. Pal., vol. 32, no. 1, pp. 58–96, pls. 5–15, 17 text-figs., (conodonts, p. 58).

GLENISTER, B. F., and GLENISTER, A. T.
1957 – *Discovery of Silurian strata from Western Australia.* Australian Jour. Sci., vol. 20, no. 4, pp. 115–116. (Biol. Abstr., 1958, vol. 32, no. 7, p. 2131.
1958 – *Discovery of subsurface Ordovician strata, Broome area, Western Australia.* Australian Jour. Sci., vol. 20, no. 6, pp. 183–184.

GRAVES, R. W., JR.
1952 – *Devonian conodonts from the Caballos novaculite.* Jour. Pal., vol. 26, no. 4, pp. 610–612, pls. 79–81, 1 text-fig. Also in: West Texas Geological Society, Guidebook, Marathon Basin, Brewster, and Pecos Counties, trans-Pecos Texas. pp. 65–66. (Zentr. Geol. Pal., 1958, pt. 2, Jahrg. 1957, no. 5, pp. 531–532.)

GREILING, L.
1957 – *Das Gotlandium des Frankenwaldes (Bayerische Entwicklung).* Geol. Jahrb., vol. 73, pp. 301–356, 15 text-figs., (conodonts, pp. 303, 344, 347).

GROSS, W.
1954 – *Zur Conodonten-Frage.* Senckenbergiana Lethaea, vol. 35, nos. 1–2, pp. 73–86, 5 pls., 2 text-figs. (Bib. Geol. Excl. North Amer., 1955, vol. 20 (1954), p. 205; Pal. Zeitschr., 1955, vol. 29, p. 4.)
1957 – *Über die Basis der Conodonten.* Pal. Zeitschr., vol. 31, nos. 1–2, pp. 78–91, pls. 7–9, 4 text-figs. (Zentr. Geol. Pal., 1958, pt. 2, Jahrg. 1957, no. 5, p. 532; Bib. Geol. Excl. North Amer., 1958, vol. 22 (1957), p. 204; Micropaleontology, 1958, vol. 4, no. 4, p. 433.)

GUTSCHICK, R. C.
1954 – *Holothurian sclerites from the Middle Ordovician of northern Illinois.* Jour. Pal., vol. 28, no. 6, pp. 827–829, 19 text-figs., (conodonts, p. 827). (Geol. Abstr., vol. 3, no. 1, p. 8.)

HARKER, P., HUTCHINSON, R. D., and MCLAREN, D. J.
1954 – *The sub-Devonian unconformity in the eastern Rocky Mountains of Canada.* In: CLARK, L. M. (Ed.), *Western Canada sedimentary basin, a symposium.* Tulsa, Amer. Assoc. Petr. Geol., pp. 48–67, (conodonts, p. 65).

HARKER, P., and RAASCH, G. O.
1958 – *Megafaunal zones in the Alberta Mississippian and Permian.* In: GOODMAN, A. J. (Ed.), *Jurassic and Carboniferous of Western Canada with related papers.* Tulsa, Amer. Assoc. Petr. Geol., pp. 216–231, 1 pl., (conodonts, pp. 229–230).

HARRIS, R. W.
1957 – *Ostracoda of the Simpson group of Oklahoma.* Oklahoma, Geol. Survey, Bull. 75, 333 pp., 10 pls., 19 text-figs., 5 range charts, (conodonts, pp. 3, 24, 25, 29, 35, 38, 40, 79, 83, 112, charts 1, 2, 3, 4).

HASS, W. H.
1950 – *Age of lower part of Stanley shale.* Amer. Assoc. Petr. Geol., Bull., vol. 34, no. 7, pp. 1578–1584, 1 table. (Bib. North Amer. Geol. (1950), 1952, p. 120; Zentr. Geol. Pal., 1951, pt. 2, Jahrg. 1950, pp. 447–448; Biol. Abstr., 1953, vol. 27, p. 767.)
1951 – *Age of Arkansas novaculite.* Amer. Assoc. Petr. Geol., Bull., vol. 35, no. 12, pp. 2526–2541, 1 pl., 2 tables.
*1953*a* *Conodonts of the Barnett formation of Texas.* U. S. Geol. Survey, Prof. Paper 243-F, pp. 69–94, pls. 14–16, text-fig. 4, table 1. (Zentr. Geol. Pal., 1958, pt. 2, Jahrg. 1957, pp. 532–533; Biol. Abstr., 1958, vol. 32, p. 30.)
1953*b* *Age of the Chattanooga shale and the Maury formation.* Geol. Soc. Amer., Bull., vol. 64, no. 12, pt. 2, p. 1532 (abstract).
1954 – *Age of some black shales in cores from northeast Mississippi.* In: Mississippi Geological Society, Guidebook, 11th Field Trip, pp. 32–33.
1956*a* *Conodonts from the Arkansas novaculite, Stanley shale and Jackfork sandstone.* In: Ardmore Geological Society, Guidebook, Ouachita Mountain Field Conference, southeastern Oklahoma, pp. 25–33, 1 pl., 1 table.
1956*b* *Age and correlation of the Chattanooga shale and the Maury formation.* U. S. Geol. Survey, Prof. Paper 286, 47 pp., 5 pls., 1 text-fig., 8 tables. (Geol. Abstr., 1958, vol. 6, no. 1, pp. 103–106.)
*1958*a* *Classification and stratigraphic range of disjunct conodonts.* Washington Acad. Sci., Jour., vol. 48, no. 4, pp. 141–142.
1958*b* *Upper Devonian conodonts of New York, Pennsylvania and interior states.* Jour. Pal., vol. 32, no. 4, pp. 765–769, 1 table.

HATTIN, D. E.
1957 – *Depositional environment of the Wreford megacyclothem (Lower Permian) of Kansas.* Kansas, Geol. Survey, Bull. 124, 150 pp., 22 pls., 6 text-figs., 2 tables, (conodonts, pp. 62, 123, 134).

HEDE, J. E.
1951 – *Boring through Middle Ordovician – Upper Cambrian strata in the Fågelsång district, Scania (Sweden).* Lunds Univ., Årsskr., N. F., avd. 2, vol. 46, no. 7, pp. 1–85, pls. 1–3.

HEMMING, F.
*1957 – *Proposed addition to the "Regles" of provisions recognizing and regulating the nomenclature of "Parataxa".* Jour. Pal., vol. 31, no. 6, pp. 1180–1183.

HENDRICKS, C. L.
1952 – *Correlation between surface and subsurface sections of the Ellenburger group of Texas.* Texas, Univ. (Bur. of Econ. Geol.), Rept. Invest., no. 11, 44 pp., 1 text-fig., 6 pls., 2 tables, (conodonts, pp. 10, 21).

HENNINGSMOEN, G.
*1948 – *The Tretaspis series of the Kullatrop core.* In: WAERN, B., THORSLUND, P., HENNINGSMOEN, G., and SÄVE-SÖDERBERGH, G., *Deep boring through Ordovician and Silurian strata.* Uppsala, Geol. Inst., Bull., vol. 32, pp. 374–432, pls. 23–25, table 4, (conodonts, pp. 374, 377, 420, 424, 432, pl. 15, fig. 14).

HERMAN, G. and BARKELL, C. A.
1957 – *Pennsylvanian stratigraphy and productive zones, Paradox salt basin.* Amer. Assoc. Petr. Geol., Bull., vol. 41, no. 5, pp. 861–881, 9 text-figs., (conodonts, p. 869).

HESSLAND, I.
1958 – *News report: Scandinavia.* Micropaleontology, vol. 4, no. 2, pp. 220–224, (conodonts, p. 223).

HIBBARD, R. R.
1951 – *Collecting and studying local microfossils.* Buffalo Mus. Sci., Hobbies, vol. 31, no. 3, pp. 46–51, 6 text-figs.

HILTERMANN, H.
1954 – *News: Germany.* The Micropaleontologist, vol. 8, no. 2, pp. 16–26.

1955 – *News reports: Germany.* Micropaleontology, vol. 1, no. 2, pp. 195–196. (Micropaleontology, 1956, vol. 2, no. 4, p. 388.)

1956 – *Annotated bibliography of micropaleontology in Germany for 1955.* Micropaleontology, vol. 2, no. 4, pp. 385–392. (Micropaleontology, 1957, vol. 3, no. 4, p. 401.)

1957*a* *News reports: Germany.* Micropaleontology, vol. 3, no. 3, p. 296.

1957*b* *Annotated bibliography of micropaleontology in Germany for 1956.* Micropaleontology, vol. 3, no. 4, pp. 399–406.

1958 – *News reports: Germany.* Micropaleontology, vol. 4, no. 2, pp. 218–219.

HOCH, U.

1958 – *Der Momberger Graben im oberhessischen Buntsandstein.* Hessen, Landesamt Bodenf., Notizbl., vol. 87, pp. 133–161, table 14, 6 text-figs., (conodonts, p. 141).

HOFFMEISTER, W. S.

1958 – *Micropaleontological analysis.* In: HAUN, J. D., and LEROY, L. W. (Eds.), *Subsurface geology in petroleum exploration.* Golden, Colorado School of Mines, pp. 203–208, (conodonts, p. 221, text-fig. 11–1, pl. 11–IV).

HOLLAND, F. D., and WALDREN, C. H.

1955 – *Conodonts in the Winnipeg formation (Ordovician) of North Dakota.* Geol. Soc. Amer., Bull., vol. 66, no. 12, pt. 2, p. 1574 (abstract).

HOWE, W. B.

1956 – *Stratigraphy of pre-Marmaton Desmoinesian (Cherokee) rocks in southeastern Kansas.* Kansas, Geol. Survey, Bull. 123, 132 pp., 10 pls., 8 text-figs., (conodonts, pp. 55, 74, 88, 132).

HOWELL, J. V., (CHM.)

1957 – *Glossary of geology and related sciences.* Washington, D. C., Amer. Geol. Inst., p. 61.

HUCKRIEDE, R.

1955 – *Conodonten in der mediterranean Trias.* Austria, Geol. Bundesanst., Verh., no. 4, pp. 260–264. (Zentr. Geol. Pal., 1957, pt. 2, Jahrg. 1956, p. 554; Micropaleontology, 1957, vol. 3, no. 4, p. 401; Zentr. Geol. Pal., 1958, pt. 2, Jahrg. 1957, no. 5, pp. 533–534.)

*1958 – *Die Conodonten der mediterranean Trias und ihr stratigraphischer Wert.* Pal. Zeitschr., vol. 32, nos. 3–4, pp. 141–175, pls. 10–14.

HUFFMAN, G. G., and others

1958 – *Geology of the south and west flanks of the Ozark Uplift, northeastern Oklahoma.* Oklahoma, Geol. Survey, Bull. 77, 281 pp., 16 tables, 22 text-figs., 6 pls., (conodonts, p. 40).

IRELAND, H. A.

1958 – *Microfauna of Wenlockian and Ludlovian Silurian beds in western England.* Geol. Soc. Amer., Bull., vol. 69, no. 12, pt. 2, p. 1592.

JICHA, H. L.

1954 – *Geology and mineral deposits of Lake Valley quadrangle, Grant, Luna, and Sierra Counties.* New Mexico, Bur. Mines and Min. Resources, Bull. 37, 93 pp., 5 pls., 8 tables, 13 text-figs., (conodonts, p. 16). (Geol. Abstr., 1954, vol. 2, no. 4, pp. 73–74.)

JONES, D. J.

1956 – *The conodonts.* In: *Introduction to microfossils.* New York; Harper and Brothers, pp. 124–142, 7 text-figs., also pp. 246, 269, 271, 273, 277, 280, 282, 283, 285.

1958*a* *News reports: United States – Rocky Mountain region.* Micropaleontology, vol. 4, no. 4, pp. 452–455, (conodonts, pp. 453–454).

1958*b* *Displacement of microfossils.* Jour. Sed. Petr., vol. 28, no. 4, pp. 453–467, 12 text-figs., (conodonts, pp. 454, 460, text-fig. 1).

JONES, T. S.

1953 – *Stratigraphy of the Permian basin of west Texas.* Midland; West Texas Geol. Soc., 63 pp., 11 text-figs., (conodonts, pp. 15, 17, 18).

KAISER, C. P.

1950 – *Stratigraphy of Lower Mississippian rocks in southwestern Montana.* Amer. Assoc. Petr. Geol., Bull., vol. 34, no. 11, pp. 2133–2175, 8 text-figs., (conodonts, pp. 2137, 2138), (Bib. North Amer. Geol. (1950), 1952, p. 144.)

KESLING, R. V.

1956 – *News reports: United States-East Central.* Micropaleontology, vol. 2, no. 3, pp. 310–312.

1957 – *News reports: United States-East Central.* Micropaleontology, vol. 3, no. 4, pp. 417–419, (conodonts, p. 418).

1958 – *News reports: United States-East Central.* Micropaleontology, vol. 4, no. 3, pp. 338–340, (conodonts, pp. 338–339).

KING, P. B.

1951 – *The tectonics of middle North America.* Princeton; Princeton Univ. Press, 203 pp., 52 text-figs., (conodonts, p. 150).

KLAPPER, G.

*1958 – *An Upper Devonian conodont fauna from the Darby formation of the Wind River mountains, Wyoming.* Jour. Pal., vol. 32, no. 6, pp. 1082–1093, pls. 141–142, 1 text-fig.

KNECHTEL, M. M., and HASS, W. H.

1953 – *Kinderhook conodonts from Little Rocky Mountains, northern Montana.* In: PARKER, J. M. (Ed.), Billings Geological Society, Guidebook, 4th Annual Field Conference, Little Rocky Mountains – Montana, southwestern Saskatchewan, pp. 83–84. (Reprinted from Jour. Pal., 1938, vol. 12, no. 5, pp. 518–520.)

KNECHTEL, M. M., SMEDLEY, J. E., and ROSS, R. L., JR.

1954 – *Little Chief Canyon member of Lodgepole limestone of Early Mississippian age in Montana.* Amer. Assoc. Petr. Geol., Bull., vol. 38, no. 11, pp. 2395–2400, 2 text-figs., (conodonts, pp. 2395, 2397, 2399).

KOCKEL, F.

1958 – *Conodonten aus dem Paläozoikum von Málaga (Spanien).* Neues Jahrb. Geol. Pal., Monatshefte, Jahrg. 1958, no. 6, pp. 255–262, 1 text-fig.

KOCKEL, C. W., and TATGE, U.

1955 – *Erster Bohrungsnachweis von Muschelkalk durch Conodonten.* Erdöl und Kohle, vol. 8, no. 9, p. 617. (Micropaleontology, 1956, vol. 2, no. 4, p. 389.)

KOTTLOWSKI, F. E., FLOWER, R. H., THOMPSON, M. L., and FOSTER, R. W.
1956 – *Stratigraphic studies of the San Andres Mountains, New Mexico.* New Mexico, Bur. Mines and Min. Resources, Mem. 1, 132 pp., 6 tables, 15 text-figs., 5 pls., (conodonts, p. 30).

KREBS, W.
1958 – *Dillenburger Tuffe.* Hessen, Landesamt Bodenf., Notizbl., vol. 86, pp. 140–152.

KRISHTOFORICHA, A. N. (Ed.)
1955 – *Konodonty.* In: *Geologichesiy Slovar.* (Geological Dictionary), vol. 1, Moscow; GOSGEOLTEKHIZDAT, p.335.

KUHN, O.
1949 – *Unterklasse Conodontophoridea.* In: *Lehrbuch der Palaozoologie.* Stuttgart; E. Schweizerbart'sche Verlagsbuchhandlung, p. 210.

LALICKER, C. G.
1950 – *News: United States-Mid Continent.* The Micropaleontologist, vol. 4, no. 3, p. 5.

LAMONT, A., and LINDSTRÖM, M.
*1957 – *Arenigian and Llandeilian cherts identified in the southern uplands of Scotland by means of conodonts, etc.* Geol. Soc. Edinburgh, Trans., vol. 17, pt. 1, pp. 60–70, 1 text-fig., pl. 5. Also in: Lund, Miner. – och Pal. – Geol. Inst., Skr. no. 35, 1957. (Bib. Geol. Excl. North Amer., 1958, vol. 22 (1957), pp. 309–310.)

LANE, N. G.
1958 – *Environment of deposition of the Grenola limestone (Lower Permian) in southern Kansas.* Kansas, Geol. Survey, Bull. 130, pt. 3, pp. 117–164, 5 text-figs., 6 pls., 9 tables, (conodonts, pp. 142, 160, table 7).

LANGE, F. W.
1954 – *News – Brazil.* The Micropaleontologist, vol. 8, no. 2, pp. 11–13, (conodonts, p. 12).

LANTZ, R. J., and FITTS, L. E.
1951 – *Tulsa Geological Society field trip no. 4.* In: Tulsa Geological Society, Guidebook, 1950–1951 season, pp. 26–34, (conodonts, pp. 28, 29).

LAUDON, L. R.
1955 – *Ages of Mississippian and Pennsylvanian faunas of western Montana and adjacent areas.* In: Billings Geological Society, Guidebook, 6th Annual Field Conference, Sweetgrass Arch and Disturbed Belt, Montana, pp. 208–210.

LEATHEROCK, C.
1950 – *Subsurface stratigraphy of Paleozoic rocks in southeastern Montana and adjacent parts of Wyoming and South Dakota.* U. S. Geol. Survey, Oil and Gas Invest. Chart OC 40.

LEROY, L. W.
1950 – *Conodonts.* In: LE ROY, L. W. (Ed.), *Subsurface geologic methods.* Golden, Colorado School of Mines, pp. 105–108, text-figs. 46–47.

LEVINSON, S. A.
1953 – *News: Gulf Coast-United States.* The Micropaleontologist, vol. 7, no. 1, pp. 4–8, (conodonts, p. 5).
1955 – *News reports: United States-Gulf Coast.* Micropaleontology, vol. 1, no. 4, pp. 387–388, (conodonts, p. 388).
1957 – *News reports: United States-Gulf Coast.* Micropaleontology, vol. 3, no. 2, pp. 202–204.

LINDSTRÖM, M.
*1954 – *Conodonts from the lowermost Ordovician strata of south-central Sweden.* Geol. Fören. Förhandl., vol. 76, no. 479, pp. 517–604, pls. 1–7, 6 text-figs. Errata: Ibid., vol. 77, p. 212, 1955; ibid., vol. 79, p. 166, 1957. Also in: Lund, Miner. – och Pal. – Geol. Inst., Skr. no. 21. (Bib. Geol. Excl. North Amer., 1955, vol. 19 (1954), p. 320; Zentr. Geol. Pal., 1956, pt. 2, Jahrg., 1955, p. 335; Biol. Abstr., 1957, vol. 31, p. 1835; Zentr. Geol. Pal., 1958, pt. 2, Jahrg. 1957, no. 5, pp. 534–536.)
*1955*a* *The conodonts described by A. R. Hadding, 1913.* Jour. Pal., vol. 29, no. 1, pp. 105–111, pl. 22, 1 text-fig. Also in: Lund, Miner. – och Pal. – Geol. Inst., Skr. no. 25. (Geol. Abstr., 1955, vol. 3, no. 1, p. 10; Bib. Geol. Excl. North Amer., 1954, vol. 20 (1955), p. 320; Zentr. Geol. Pal., 1958, pt. 2, Jahrg. 1957, no. 5, p. 536.)
1955*b* *Om conodonter.* Svensk Faunistik Revy, vol. 17, no. 3, pp. 76–79.
*1957 – *Two Ordovician conodont faunas found with zonal graptolites.* Geol. Fören, Förhandl., vol. 79, no. 2, pp. 161–178, pls. 1–2, 2 text-figs., 1 table. Also in: Lund, Miner. – och Pal. – Geol. Inst., Skr. no. 34. (Geol. Abstr., 1957, vol. 5, no. 4, p. 90; Zentr. Geol. Pal., 1958, pt. 2, Jahrg. 1957, no. 5, p. 537; Bib. Geol. Excl. North Amer., 1958, vol. 22 (1957), p. 323.)

LIPPERT, H. J.
1955 – *Aus dem Roteisenstein – Bergbau an Lahn und Dill.* Deutsch. Geol. Ges. Zeitschr., vol. 105, Jahrg. 1953, pp. 20–24, 1 text-fig., (conodonts, p. 22).

LOEBLICH, A. R., JR.
1955 – *News reports: Eastern United States.* Micropaleontology, vol. 1, no. 1, pp. 96–98, (conodonts, pp. 97–98).
1956 – *News reports: United States-Eastern.* Micropaleontology, vol. 2, no. 1, pp. 98–101, (conodonts, pp. 99–100).
1957 – *News reports: United States-East Coast.* Micropaleontology, vol. 3, no. 2, pp. 200–202, (conodonts, p. 201).

LONGWELL, C. B.
1952 – *Edwin Bayer Branson.* Amer. Assoc. Petr. Geol., Bull., vol. 35, no. 7, pp. 1706–1710, 1 text-fig. (Memorial.) (Biol. Abstr., 1951, vol. 25, p. 2869.)

LORANGER, D. M.
1958 – *Mississippian micropaleontology applied to the western Canada basin.* In: GOODMAN, A. J. (ed.), *Jurassic and Carboniferous of western Canada with related papers.* Tulsa; Amer. Assoc. Petr. Geol., pp. 232–243, 10 text-figs., (conodonts, p. 241).

LYS, M., and SERRE, B.
1957*a* *Présence de conodontes dans le Paléozoïque du Sahara (région d'Adrar-Tanezrouft).* Acad. Sci., C. R., vol. 244, no. 7, pp. 916–918. (Zentr. Geol. Pal., 1958, pt. 2, Jahrg. 1957, no. 5, p. 537; Bib. Geol. Excl. North Amer., 1958, vol. 22 (1957), p. 332.)
1957*b* *Découverte de conodontes dans le Paléozoïque de la Montagne Noire.* Acad. Sci., C. R. vol. 244, no. 15, pp. 2071–2073. (Zentr. Geol. Pal., 1958, pt. 2, Jahrg. 1957, no. 5, pp. 537–538; Bib. Geol. Excl. North Amer., 1958, vol. 22 (1957), p. 332.)

1957*c* *Étude de conodontes du Dévonien et du Carbonifère de la région d'Adrar-Tanezrouft (Sahara).* Inst. Franç. Pétrole, Rev., vol. 12, no. 10, pp. 1035–1066, 7 pls., 1 text-fig., 1 table. (Bib. Geol. Excl. North Amer., 1958, vol. 22 (1957), p. 332.)

1958 – *Contribution a la Connaissance des microfaunes du Paléozoïque. Études Micropaléontologiques dans les Carbonifère mariu des Asturies (Espagne).* Inst. Franç. Pétrole, Rev., vol. 13, no. 6, pp. 879–916, 11 pls., 2 tables, 1 text-fig., (conodonts, pp. 879, 881, 890–893, 910, 911, pl. 9, table 2).

LYS, M., SERRE, B., and DEROO, G.

*1957 – *Études micropaléontologiques dans le Paléozoique de la Montagne Noire (foraminifères, conodontes, etc.).* Inst. Franç. Pétrole, Rev., vol. 12, nos. 7–8, pp. 783–833, 12 pls., 3 text-figs., 2 tables, 1 map. (Bib. Geol. Excl. North Amer., 1958, vol. 22 (1957), p. 332.)

MACDONALD, G. H.

1956 – *Subsurface stratigraphy of the Mississippian rocks of Saskatchewan.* Canada, Geol. Survey, Mem. 282, 46 pp., 12 figs., (conodonts, pp. 11, 13, 16, 17, 18).

MAGNE, J.

1958 – *News reports: North Africa.* Micropaleontology, vol. 4, no. 4, pp. 448–450, (conodonts, p. 449).

MAGRAW, D.

1957 – *New borcholes into the lower Coal Measures below the Arley mine of Lancashire and adjacent areas.* (With notes by EARP, J. R., and TAYLOR, B. J.) Great Britain, Geol. Survey, Bull. 13, pt. 3, pp. 14–38, pl. 3, 4 text-figs., (conodonts, pp. 21–23, 37, 38). (Bib. Geol. Excl. North Amer., 1958, vol. 22 (1957), p. 336.)

MAHER, J. C., and COLLINS, J. B.

1952 – *Correlation of Permian and Pennsylvanian rocks from western Kansas to the Front Range of Colorado.* U. S. Geol. Survey, Oil and Gas Invest. Chart. OC 46, 3 sheets, (conodonts, sheet 3).

MALZAHN, E.

1957 – *Neue Fossilfunde und vertikale Verbreitung der niederrheinischen Zechsteinfauna in den Bohrungen Kamp 4 und Friedrich Heinrich 57 bei Kamp-Lintfort.* Geol. Jahrb., vol. 73, pp. 91–126, pls. 10–14, 1 text-fig., 1 table., (conodonts, p. 95, 108, 114, 115, pl. 11, figs. 17–23). (Micropaleontology, vol. 4, no. 4., p. 435.)

MANSON, W.

1957 – *On the occurrence of a marine band in the Anthraconaia modiolaris zone of the Scottish Coal Measures with notes on certain of the marine fossils by Calver, M. A.* Great Britain, Geol. Survey, Bull. 12, pt. 5, pp. 66–86, 4 text-figs., (conodonts, pp. 72, 79, 80, 82, 84). (Bib. Geol. Excl. North Amer., 1958; vol. 22–1957, p. 1835.)

MARKS, E.

1952 – *The Helen Jeanne Plummer collections.* The Micropaleontologist, vol. 6, no. 4, pp. 30–47, (conodonts, p. 31).

MARPLE, M. F.

1951 – *Microfauna of the Pottsville series in Ohio.* Geol. Soc. Amer., Bull., vol. 62, no. 12, pt. 2, p. 1462 (abstract).

MATTHES, H. W.

1956 – *Conodonten.* In: *Einführung in die Mikropaläontologie.* Leipzig; S. Hirzel, pp. 157–176, figs. 82–88, table 10, also pp. 240, 244.

1957 – *Der gegenwärtige Stand der Mikropaläontologischen Forschung.* Forschungen und Fortschritte, vol. 31, no. 2, pp. 33–39, (conodonts, pp. 38–39). (Micropaleontology, 1958, vol. 4, no. 4, pp. 435–436.)

MCCOY, R. M.

1952 – *Ordovician sediments in the northern Black Hills.* In: SONNENBERG, F. P. (Ed.), Billings Geological Society, Guidebook, 3rd Annual Field Conference, Black Hills and Williston Basin. pp. 44–47, 2 text-figs.

1958 – *Ordovician rocks of the northern Powder River Basin and Black Hills Uplift areas, Montana, Wyoming and South Dakota.* In: STRICKLAND, J. (Ed.), Wyoming Geological Association, 13th Annual Field Conference, Powder River Basin. pp. 25–30, 1 text-fig.

MCLAREN, D. J.

1954 – *Upper Devonian Rhynchonellid zones in the Canadian Rocky Mountains.* In: CLARK, L. M. (Ed.), Western Canada sedimentary basin, a symposium. Tulsa; Amer. Assoc. Petr. Geol., pp. 159–181, (conodonts, p. 163).

MCLAUGHLIN, K. P.

1952 – *Microfauna of the Pennsylvanian Glen Eyrie formation, Colorado.* Jour. Pal., vol. 26, no. 4, pp. 615–621, pls. 82–83. Errata: Ibid., vol. 27, no. 2, p. 298, 1953. (Zentr. Geol. Pal., 1958, pt. 2, Jahrg. 1957, no. 5, p. 538.)

MCMILLAN, N. J.

1956 – *Petrology of the Nodaway underclay (Pennsylvanian) Kansas.* Kansas, Geol. Survey, Bull. 119, pt. 6, pp. 187–249, 10 text-figs., 4 pls., (conodonts, p. 202).

MCWHAE, J. R. H., PLAYFORD, P. E., LINDNER, A. W., GLENISTER, B. F., and BALME, B. E.

1958 – *The stratigraphy of Western Australia.* Geol. Soc. Australia, Jour., vol. 4, pt. 2, pp. 1–161, 10 text-figs., (conodonts, pp. 28, 30, 31, 40, 43, 44, 49).

MELLEN, F. F.

1955 – *Subsurface outliers of Chattanooga shale in northeastern Mississippi.* Amer. Assoc. Petr. Geol., Bull., vol. 39, no. 9, pp. 1864–1865.

MEMPEL, G.

1950 – *Die Beziehungen der Pericyclus-Fauna des Gr. Schachttales zum Acker-Bruchbergsystem (Harz).* Geol. Landesanstalt, N. F., Abh., vol. 216, pp. 3–7, (conodonts, p. 5). (Bib. Geol. Excl. North Amer., 1953, vol. 17 (1952), p. 294.)

MICKELSON, J. C.

1956 – *Madison group in central Montana.* In: Foster, D. I. (Ed.), Billings Geological Society, Guidebook, 7th Annual Field Conference, central Montana, pp. 68–72, (conodonts, p. 68).

MILLER, H. W., and SWINEFORD, A.

1957 – *Paleoecology of nodulose zone at top of Haskell limestone (Upper Pennsylvanian) in Kansas.* Amer. Assoc. Petr. Geol., Bull., vol. 41, no. 9, pp. 2012–2036, 7 text-figs., 3 pls., (conodonts, pp. 2012, 2027, 2028, 2034). (Geol. Abstr., 1957, vol. 5, no. 4, p. 3.) Review: Oklahoma Geol. Survey, Geol. Notes, vol. 17, no. 11, pp. 109–110.

MIRCHINKA, M. F. (ED.)
1958 – *Konodonty.* In: *Slovar po geologii nefti. (Dictionary of petroleum geology.)* 2nd Ed., Leningrad; GOSTOPTEKHIZDAT, p. 305.

MITCHELL, G. H.
1954 – *The Whittington Heath borehole.* (with appendices by SABINE, P. A., and PONSFORD, D. R. A. Great Britain, Geol. Survey, Bull., no. 5, pt. 1, pp. 1–60, pl. 1, 4 text-figs., (conodonts, pp. 16, 20). (Bib. Geol. Excl. North Amer., 1955, vol. 19 (1954), p. 323.)

MITCHELL, G. H., and STUBBLEFIELD, C. J.
1941 – *The geology of the Leicestershire and south Derbyshire coalfield.* Great Britain, Geol. Survey, Wartime Pamphlet, no. 22, 46 pp., 8 text-figs., 2 tables, (conodonts, pp. 7, 29, 45, table 2).

MITCHELL, G. H., STUBBLEFIELD, C. J., and CROOKALL, R.
1942 – *The geology of the Warwickshire coalfield.* Great Britain, Geol. Survey, Wartime Pamphlet, no. 25, 38 pp., 12 text-figs., (conodonts, pp. 19, 21, table 2).
1945 – *The geology of the northern part of the south Staffordshire coalfield.* Great Britain, Geol. Survey, Wartime Pamphlet, no. 43, 48 pp., 11 text-figs., 3 tables, (conodonts, p. 23, text-fig. 11a, table 3).

MOORE, R. C., FRYE, J. M., JEWETT, W. L., and O'CONNOR, H. G.
1951 – *The Kansas rock column.* Kansas, Geol. Survey, Bull. 89, 132 pp., 52 text-figs., (conodonts, pp. 64–66).

MOORE, R. C., LALICKER, C. G., and FISCHER, A. G.
1956 – *Conodonts.* In: *Invertebrate fossils.* New York; McGraw-Hill Book Co., pp. 733–738, 2 text-figs.

MOORE, R. C., and SYLVESTER-BRADLEY, P. C.
*1956 – *Problems of scientific nomenclature applicable to fragmentary fossils.* Jour. Sed. Petr., vol. 26, no. 2, p. 180; Jour. Pal., vol. 30, no. 4, p. 999 (abstract).
*1957 – *Suggested new article: Proposed recognition of the concept "parataxon" and the provisions of rules for the nomenclature of units of this category.* Bull. Zool. Nomencl., vol. 15, section A, pp. 5–13. (For comments about this suggestion see: Ibid., section A, pp. 14–120, 156–184, 216–246, 305–314, 345–350, 619–620; Ibid., section B, pp. 686–690, 705–728, 759–761, 826–851, 968–973, 1241.)

MÜLLER, K. J.
*1956*a* *Triassic conodonts from Nevada.* Jour. Pal., vol. 30, no.4, pp. 818–830, pls. 95–96. (Geol. Abstr., 1956, vol. 4, no. 4, p. 61; Zentr. Geol. Pal., 1958, pt. 2, Jahrg. 1957, no. 5, p. 539.)
1956*b* *Upper Devonian substages and their world-wide correlation on the basis of conodonts.* Jour. Pal., vol. 30, no. 4, p. 1011; also in Jour. Sed. Petr., 1956, vol. 26, no. 2, p. 192 (abstract).
*1956*c* *Zur Kenntnis der Conodonten – Fauna des europäischen Devons, 1 – Die Gattung Palmatolepis.* Senckenbergische Naturf. Ges., Abh., no. 494, 70 pp., 11 pls., 1 fig., 2 tables. (Micropaleontology, 1957, vol. 4, no. 2, p. 403; Bib. Geol. Excl. North Amer., 1958, vol. 21 (1956), p. 420.
*1956*d* *Taxonomy, nomenclature, orientation, and stratigraphic evaluation of conodonts.* Jour. Pal., vol. 30, no. 6, p. 1324–1340, pl. 145. (Geol. Abstr., 1957, vol. 5, no. 1, p. 28; Zentr. Geol. Pal., 1958, pt. 2, Jahrg. 1957, no. 5, p. 539.)
1958 – *Conodonten der oberdevonischen Independence-Schichten in Iowa.* Pal. Zeitschr., vol. 32, p. 9 (abstract).

MÜLLER, K. J., and MÜLLER, E. M.
*1957 – *Early Upper Devonian (Independence) conodonts from Iowa, part I.* Jour. Pal., vol. 31, no. 6, pp. 1069–1108, pls. 135–142, 8 text-figs. (Geol. Abstr., 1958, vol. 6, no. 1, p. 2.)

MURCHISON, A. R., JR.
1958 – *Caballos novaculite.* In: Fillman, L. (Chm.), *Lexicon of pre-Pennsylvanian stratigraphic names of west Texas and southeastern New Mexico.* Midland; West Texas Geol. Soc., pp. 27–28.

MUTVEI, H.
1956 – *Découverte d'une riche microfaune dans le calcaire silurien de la région de la Saoura (Sahara du Nord).* Acad. Sci., C. R., vol. 243, no. 21, pp. 1653–1654. (Bib. Geol. Excl. North Amer., 1958, vol. 21 (1956), p. 379.)

NILSSON, R.
1951 – *Till Kännedomen om ordovicium i sydöstra Skåne.* Geol. Fören. Förhandl., vol. 73, no. 4, pp. 682–694, (conodonts, pp. 685, 687).

NOLAN, T. B., MERRIAM, C. W., and WILLIAMS, J. S.
1956 – *The stratigraphic section in the vicinity of Eureka, Nevada.* U. S. Geol. Survey, Prof. Paper 276, 77 pp., 2 pls., 2 text-figs. (conodonts, p. 53).

O'CONNOR, H. G.
1955 – *Rock formations of Osage County, Part 1 of Geology and mineral resources and ground-water resources of Osage County, Kansas.* Kansas, Geol. Survey, Rept., vol. 13, pp. 5–20, 1 text-fig., pls. 1, 4, (conodonts, pp. 16–18).

OPIK, A. A.
1929 – *Der estlandische Obolenphosphorit.* Tartu, Univ. Geol. Inst., publ., no. 18, pp. 1–49, 6 text-figs., 2 maps, (conodonts, p. 16).
1956 – *Cambrian (Lower Cambrian) of Estonia.* In: *El sistema Cambrico, Paleogeografia y el problema de su base, symposium, pt. 1.* Intern. Geol. Congr., 20th, Mexico, pp. 97–126, figs. 1–4, tables 1–3, (conodonts, pp. 99, 100, 110).

ØRVIG, T.
1958 – *Pycnaspis splendens, new genus, new species, a new ostracoderm from the Upper Ordovician of North America.* U. S. Nat. Mus., Proc., vol. 108, no. 3391, 23 pp., 3 pls., 5 text-figs., (conodonts, pp. 4, 5, 16).

PAYTON, C. E., and THOMAS, L. A.
1958 – *Petrology of some Pennsylvanian black "shales".* Geol. Soc. Amer., Bull., vol. 69, no. 12, pt. 2, p. 1628 (abstract).

PECK, R. E.
1953 – *News: Midcontinent – United States.* The Micropaleontologist, vol. 7, no. 3, pp. 2–3.

PHILPOTT, T. H.
1952 – *Paleofacies, the geologists new tool.* Amer. Assoc. Petr. Geol., Bull., vol. 36, no. 7, pp. 1305–1317, 15 text-figs., (conodonts, p. 1306). Also in: Petr. Engineering, 1952, vol. 24, no. 8, pp. 91–104; Summary in Oil and Gas Jour., 1952, vol. 50, no. 46, pp. 164–165; and World Oil, 1952, vol. 134, no. 5, p. 84.

PILGER, A., and SCHONEBERG, R.
1958 – *Der erste Fund mitteltriadischer Tuffe in den gailtaler Alpen (Kärnten)*. Deutsch. Geol. Ges. Zeitschr., vol. 110, pp. 205–214, 3 text-figs., 3 pls.

POKORNÝ, V.
1954 – *Základy zoologické mikropaleontologie*. Prague; Tschechoslowakische Akademie der Wissenschaften, 651 pp., 756 figs. Review: Geologie, 1956, vol. 5, no. 6, pp. 552–553 (not seen).
1958 – *Conodonten*. In: *Grundzüge der zoologischen Mikropaläontologie*. Berlin; VEB Deutscher Verlag der Wissenschaften, vol. 2, pp. 37–65, text-figs. 572–611, also pp. 371–375.

RAASCH, G. O.
1958 – *Discussion of Carboniferous papers*. In: GOODMAN, A. J. (Ed.). *Jurassic and Carboniferous of western Canada with related papers*. Tulsa; Amer. Assoc. Petr. Geol., pp. 502–503.

RABIEN, A.
1956 – *Zur Stratigraphic und Fazies des Ober-Devons in der Waldecker Hauptmulde*. Hessen, Landesamt Bodenf., Abh., no. 16, 83 pp., 2 text-figs., 2 tables, 2 pls., (conodonts, pp. 15, 26, 29, 56, 76, table 2).

RABIEN, A., and RABITZ, A.
1958 – *Das Ober-Devon von Meschede*. Hessen, Landesamt Bodenf., Notizbl., vol. 86, pp. 159–184, 5 text-figs., 3 tables, (conodonts, pp. 168, 175–177, 181, 182).

RAMSBOTTOM, W. H. C.
1952 – *The fauna of the Cefn Coed Marine Band in the Coal Measures at Aberbaiden, near Tondu, Glamorgan*. Great Britain, Geol. Survey, Bull. 4, pt. 2, pp. 8–32, pls. 2–3, (conodonts, p. 9). (Bib. Geol. Excl. North Amer., 1954, vol. 18 (1953), p. 334.

RANDALL, A. G.
1958 – *Catalog of formation names for Powder River Basin, Wyoming*. In: STRICKLAND, J. (Ed.), Wyoming Geological Association, 13th Annual Field Conference, Powder River Basin. pp. 280–287, (conodonts, pp. 283, 285).

REED, E. W., SCHOFF, S. L., and BRANSON, C. C.
1955 – *Ground-water resources of Ottawa county, Oklahoma*. Oklahoma, Geol. Survey, Bull. 72, 203 pp., 1 pl., 14 text-figs., 14 tables, (conodonts, p. 45).

REICHSTEIN, M.
1958 – *Neue stratigraphische Ergebnisse aus der Schichtenfolge vom Unterdevon bis zum Unterkarbon in der Umrandung des Elbingeröder Komplexes (Harz)*. Neues Jahrb. Geol. Pal., Monatshefte, Jahrg. 1958, pp. 551–558.

REXROAD, C. B.
1956 – *Conodonts from the type Chester, Illinois*. Jour. Pal. vol. 30, no. 4, pp. 1010–1011 (abstract). Also in: Jour. Sed. Petr., 1956, vol. 26, no. 2, pp. 191–192.
*1957 – *Conodonts from the Chester series in the type area of southwestern Illinois*. Illinois, Geol. Survey, Rept. Invest. 199, 43 pp., 4 pls., 1 table, 21 text-figs. (Geol. Abstr., 1957, vol. 5, no. 1, p. 82; Zentr. Geol. Pal., 1958, pt. 2, Jahrg. 1957, no. 5, pp. 540–541.)
*1958*a* *Conodonts from the Glen Dean formation (Chester) of the Illinois basin*. Illinois, Geol. Survey, Rept. Invest. 209, 27 pp., 6 pls., 14 text-figs., 1 table. (Geol. Abstr., vol. 6, no. 4, p. 99.)
*1958*b* *The conodont homeomorphs Taphrognathus and Streptognathodus*. Jour. Pal., vol. 32, no. 6, pp. 1158–1159.

RHODES, F. H. T.
*1952 – *A classification of Pennsylvanian conodont assemblages*. Jour. Pal., vol. 26, no. 6, pp. 886–901, pls. 126–129, 4 text-figs. (Biol. Abstr., 1954, vol. 28, p. 2960.)
*1953*a* *Nomenclature of conodont assemblages [with a] footnote on a correction of the name "Scottella"*. Jour. Pal., vol. 27, no. 4, pp. 610–612. (Biol. Abstr., 1956, vol. 27, no. 4, p. 1517.)
*1953*b* *Some British lower Paleozoic conodont faunas*. Royal Soc. London, Philos. Trans., series B, vol. 237, no. 647, pp. 261–334, pls. 20–23, text-figs. 1–20. (Bib. Geol. Excl. North Amer., 1954, vol. 18 (1953), p. 340; Biol. Abstr., 1955, vol. 29, pt. 2, pp. 1519–1520.)
1954 – *The zoological affinities of the conodonts*. Cambridge Philos. Soc., Biol. Reviews, vol. 29, pp. 419–452, 6 text-figs. (Bib. Geol. Excl. North Amer., 1955, vol. 19 – 1954, p. 390.)
*1955 – *The conodont fauna of the Keisley limestone*. Geol. Soc. London, Quart. Jour., vol. 111, pp. 117–142, pls. 7–10, 6 text-figs. (with discussion). (Bib. Geol. Excl. North Amer., 1957, vol. 20 (1955), p. 443; Zentr. Geol. Pal., 1957, pt. 2, Jahrg. 1956, pp. 140–141; Ibid., 1958, Jahrg. 1957, no. 5, p. 541.)

RHODES, F. H. T., and DINELEY, D. L.
*1957*a* *Devonian conodont faunas from southwest England*. Jour. Pal., vol. 31, no. 2, pp. 353–369, pls. 37–38, 10 text-figs., 1 table. (Geol. Abstr., 1957, vol. 5, no. 2, p. 22; Ibid., 1957, vol. 5, no. 3, p. 21; Bib. Geol. Excl. North Amer., 1957, vol. 20 (1955), p. 447.)
1957*b* *Supplementary notes on Devonian conodont faunas from southwest England*. Jour. Pal., vol. 31, no. 6, p. 1175.

RHODES, F. H. T., and MÜLLER, K. J.
*1956 – *The conodont genus Prioniodus and related forms*. Jour. Pal., vol. 30, no. 3, pp. 695–699, 1 table. (Bib. Geol. Excl. North Amer., 1958, vol. 21 (1956), p. 491; Zentr. Geol. Pal., 1958, pt. 2, Jahrg. 1957, no. 5, pp. 541–542.)

RHODES, F. H. T., and WINGARD, P. S.
*1957 – *Chemical composition, microstructure, and affinities of the neurodontiformes*. Jour. Pal., vol. 31, no. 2, pp. 448–454, 2 text-figs. (Bib. Geol. Excl. North Amer., 1957, vol. 20 (1955), p. 447.)

RICE, C. M.
1955 – *Dictionary of geological terms (exclusive of stratigraphic formations and paleontological genera and species)*. Ann Arbor; Edwards Brothers, Inc., (conodonts, p. 85).

RICH, J. L.
1953 – *Paleogeographic implications of evidences pointing to fondo origin of the Chattanooga-New Albany-Ohio bituminous shales*. Geol. Soc. Amer., Bull., vol. 64, no. 12, pp. 1535–1536 (abstract).

ROBBIE, J. A.
1955 – *The Carboniferous rocks of Edendork, County Tyrone*. Great Britain, Geol. Survey, Bull. 8, pt. 2, pp. 21–37, 3 text-figs., (conodonts, pp. 25, 28, 30, text-fig. 1). (Bib. Geol. Excl. North Amer., 1957, vol. 20 (1955), p. 449.)

ROBERTS, R. J., HOTZ, P. E., GILLULY, J., and FERGUSON, H. G.
1958 – *Paleozoic rocks of north-central Nevada*. Amer. Assoc. Petr. Geol., Bull., vol. 42, no. 12, pp. 2813–2857, 11 text-figs., (conodonts, p. 2837).

ROBERTSON, G. M.
1953 – *Some attempts at phylogeny of early vertebrates.* Iowa Acad. Sci., Proc., vol. 60, pp. 725–737, 2 text-figs., (conodonts, p. 733).

ROGER, J.
1952 – *Conodontes.* In: PIVETEAU, J. (Ed.), *Traité de Paléontologie.* Paris; Masson et Cie, vol. 2, pp. 173–179, text-figs. 11–17, also pp. 199–202. (Biol. Abstr. 1955, vol. 29, p. 1773.)

ROSS, R. J., JR.
1957 – *Ordovician fossils from wells in the Williston basin, eastern Montana.* U. S. Geol. Survey, Bull. 1021-M, pp. 439–510, pls. 37–44, text-figs. 67–69, 1 insert, (conodonts, pp. 439, 445, 460–463, 468–469).
1958 – *Trilobites in a pillow-lava of the Ordovician Valmy formation, Nevada.* Jour. Pal., vol. 32, no. 3, pp. 559–570, pls. 83–84, (conodonts, p. 559). (Geol. Abstr., vol. 6, no. 3, p. 57.)

RÜGER, L.
1934 – *Die Baltischen Länder.* Heidelberg; Carl Winters Universitätsbuchhandlung, Handbuch der Regionalen Geologie, vol. 4, pt. 4, no. 28, pp. 1–79, pl. 1, figs. 1–14, (conodonts, pp. 13, 15–16). [Not seen.]

SABINS, F. F.
1957 – *Stratigraphic relations in Chiricahua and Dos Cabezas mountains, Arizona.* Amer. Assoc. Petr. Geol., Bull., vol. 41, no. 3, pp. 466–510, 15 text-figs., (conodonts, p. 478). (Geol. Abstr., vol. 5, no. 2, p. 6.)

SANDO, W. J.
1958 – *Lower Ordovician section near Chambersburg, Pennsylvania.* Geol. Soc. Amer., Bull., vol. 69, no. 7, pp. 837–854, 2 text-figs., 2 pls. (Geol. Abstr., vol. 6, no. 3, p. 80.)

SANNEMANN, D.
1953 – *Neue stratigraphische Ergebnisse im Paläozoikum des Frankenwaldes auf Grund von Conodontenfunden.* Neues Jahrb. Geol. Pal., Monatshefte, Jahrg. 1953, pp. 480–482. (Zentr. Geol. Pal., 1954, pt. 2, Jahrg. 1954, pp. 5–6; Bib. Geol. Excl. North Amer., 1955, vol. 19 (1954), p. 416.)
1954 – *Obersilurischer Vulkanismus und Grenze Silur-Devon in der bayerischen Facies des Frankenwaldes.* Neues Jahrb. Geol. Pal., Monatshefte, vol. 12, Jahrg. 1954, pp. 433–439, 1 text-fig., 1 table. (Zentr. Geol. Pal., 1956, pt. 2, Jahrg. 1955, p. 611; Bib. Geol. Excl. North Amer., 1957, vol. 20 (1955), p. 469.)
*1955*a* *Beitrag zur Untergliederung des Oberdevons nach Conodonten.* Neues Jahrg. Geol. Pal., Abh., vol. 100, pp. 324–331, pl. 24, 1 text-fig., 1 table. (Zentr. Geol. Pal., 1956, pt. 2, Jahrg. 1955, pp. 613–614; Micropaleontology, 1956, vol. 2, no. 4, p. 390; Bib. Geol. Excl. North Amer., 1958, vol. 21 (1956), p. 519; Zentr. Geol. Pal., pt. 2, Jahrg. 1957, no. 5, pp. 542–543, 1958.)
*1955*b* *Oberdevonische Conodonten (to IIα).* Senckenbergiana Lethaea, vol. 36, nos. 1–2, pp. 123–156, 6 pls., 12 text-figs. (Micropaleontology, 1956, vol. 2, no. 4, p. 390; Bib. Geol. Excl. North Amer., 1957, vol. 20 (1955), p. 469; Zentr. Geol. Pal., 1958, pt. 2, Jahrg. 1957, no. 5, pp. 544–545.)
*1955*c* *Ordovicium und Oberdevon von der bayerischen Fazies des Frankenwaldes nach Conodontenfunden.* Neues Jahrb. Geol. Pal., Abh., vol. 102, no. 1, pp. 1–36, pls. 1–3, 3 text-figs., 1 table. (Micropaleontology, 1956, vol. 2, no. 4, p. 390; Zentr. Geol. Pal., 1958, pt. 2, Jahrg. 1957, pp. 543–544.)

SCHINDEWOLF, O. H.
1950 – *Stellung und stratigraphische Bedeutung der Mikropaläontologie.* In: *Grundfragen der Paläontologie.* Stuttgarts; E. Schweizerbart'sche Verlagsbuchhandlung, pp. 74–81, (conodonts, pp. 75–76, text-figs. 94–99).
1954*a* *Über die Faunenwende vom Paläozoikum zum Mesozoikum.* Deutsch. Geol. Ges., Zeitschr., vol. 105, no. 2, pp. 153–182, 5 text-figs., 3 tables, pls. 5–6, (conodonts, p. 154, table 3).
1954*b* *Über die möglichen Ursachen der grossen erdgeschichtlichen Faunenschnitte.* Neues Jahrb. Geol. Pal., Monatshefte, Jahrg. 1954, pp. 457–465, 3 tables, (conodonts, table 3). (Bib. Geol. Excl. North Amer., 1957, vol. 20 (1955), p. 475.)

SCHMIDT, F.
1897 – *Excursion durch Estland.* In: *Guide des Excursions.* Intern. Geol. Congr., 7th, Russia, pt. 12, 21 pp., 3 figs., (conodonts, p. 4).

SCHMIDT, H.
1950 – *Nachträge zur Deutung der Conodonten.* Decheniana, vol. 104, pp. 11–19, figs. 1–7. (Zentr. Geol. Pal., 1952, pt. 2, Jahrg. 1951, pp. 59–60; Biol. Abstr., 1952, vol. 25, pt. 3, p. 2931.)
1958 – *Die Conodonten in Geologie und Paläontologie.* Die Umschau über die Fortschritte in Wissenschaft und Technik, vol. 58, no. 17, pp. 517–520, text-figs. 1–5.

SCHMIDT, W., and TEICHMÜLLER, M.
1955 – *Die Enträtselung eines bislang unbekannten Fossils im deutschen Oberkarbon, Sphenothallus stubblefieldi n. sp., und die Art seines Auftretens.* Geol. Jahrb., vol. 71, pp. 243–298, pls. 20–27, 3 text-figs., (conodonts, pp. 248, 249, 251, 252, 254–256, 264, 266, 268, 278, 286, 287, pl. 22, figs. 1–6).

SCHRIEL, W. and STOPPEL, D.
1958 – *Das Alter der Hauptkieselschiefer Lossen's und der Buntschiefer in der Südharzmulde.* Deutsch. Geol. Ges., Zeitschr. Jahrg. 1957, vol. 109, pt. 2, pp. 559–565.

SCHWAN, W.
1950 – *Die Acker-Bruchbergschichten des Harzes.* Geol. Landesanst., N. F., Abh., vol. 216, pp. 9–47, 8 pls., 55 text-figs., (conodonts, pp. 15–19, text-fig. 4). (Zentr. Geol. Pal., 1952, pt. 2, Jahrg. 1951, p. 60; Biol. Abstr., 1951, vol. 25, p. 2011; Bib. Geol. Excl. North Amer., 1953, vol. 17 (1952), p. 389.)
1958 – *Zur Neugliederung der Acker-Bruchbergschichten nach Conodonten, speziell bei Harsburg.* Geologie, vol. 7, no. 8, pp. 991–1017, 5 text-figs., (conodonts, pp. 991–1000).

SCOTT, A. J.
1957 – *Growth stages and specific variation in Devonian-Mississippian conodonts.* Geol. Soc. Amer., Bull., vol. 68, no. 12, pt. 2, pp. 1794–1795 (abstract).

SCUPIN, H.
1928 – *Ostbaltikum (part 1). Algonkium, Paläozoikum und Mesozoikum.* Berlin; Gebrüder, Borntraeger, Die Kriegsschauplätze 1914–1918 geologisch dargestellt, part 9, (conodonts, pp. 45, 47, 55, 171).

SECOR, D.
1958 – *Fusselman limestone.* In: Fillman, L. (Chm.) *Lexicon of pre-Pennsylvanian stratigraphic names of west Texas and southeastern New Mexico.* Midland; West Texas Geol. Soc., pp. 53–57, (conodonts, p. 57).

SHROCK, R. R., and TWENHOFEL, W. H.
1953 – *Conodontophoridia (conodonts).* In: *Principles of invertebrate paleontology.* New York; McGraw Hill Book Co., pp. 768–782, 8 text-figs.

SINCLAIR, G. W.
*1953 – *The naming of conodont assemblages.* Jour. Pal., vol. 27, no. 3, p. 489–491. (Biol. Abstr., 1956, vol. 30, p. 1517.)

SINGLETARY, C. E.
1958 – *Woodford shale.* In: FILLMAN, L. (Chm.), *Lexicon of pre-Pennsylvanian stratigraphic names of west Texas and southeastern New Mexico.* Midland; West Texas Geol. Society, pp. 144–145.

SMITH, M. L.
1956 – *Some ostracods from the Middle Devonian Ledyard and Wanakah members of the Ludlowville formation in western New York.* Jour. Pal., vol. 30, no. 1, pp. 1–8, pl. 1, 1 table, 1 text-fig., (conodonts, p. 2). (Geol. Abstr., vol. 4, no. 2, p. 48.)

SOFIANO, T. A.
1957 – *Anglo-Russkiy Geologicheskii Slovar.* (*English-Russian Geological Dictionary.*) Moscow; State Publishing Office for Technical and Theoretical Literature, p. 119.

STAINFORTH, R. M.
1956 – *News reports: United States – North Central.* Micropaleontology, vol. 2, no. 1, pp. 103–104.
1957 – *News reports: United States – Rocky Mountain region.* Micropaleontology, vol. 3, no. 4, pp. 419–420.

STANLEY, E. A.
*1958 – *Some Mississippian conodonts from the High Resistivity shale of the Nancy Watson No. 1 well in northeastern Mississippi.* Jour. Pal., vol. 32, no. 3, pp. 459–476, pls. 63–68, 2 text-figs., 2 tables. (Geol. Abstr., vol. 6, no. 3, pp. 54–55.)

STEVENSON, I. P., and MITCHELL, G. H.
1955 – *Carboniferous rocks.* In: STEVENSON, I. P., and MITCHELL, G. H., with others, *Geology of the country between Burton upon Trent, Rugeley and Uttoxeter.* Great Britain, Geol. Survey, Mem., pp. 10–19, text-figs. 3–4, (conodonts, pp. 11, 12).

STEWART, G. A.
1950 – *Ostracoda from the Middle Devonian Bone beds in central Ohio.* Jour. Pal., vol. 24, no. 6, pp. 652–666, pls. 85–86, 1 table, (conodonts, p. 652). (Bib. North Amer. Geol. (1950), 1952, p. 247.)

STEWART, G. A., and SWEET, W. C.
*1956 – *Conodonts from the Middle Devonian Bone beds of central and west-central Ohio.* Jour. Pal., vol. 30, no. 2, pp. 261–273, pls. 33–34, 1 text-fig. (Geol. Abstr., 1956, vol. 4, no. 2, p. 56; Zentr. Geol. Pal., 1958, pt. 2, Jahrg. 1958, no. 5, pp. 545–546.)

STOPPEL, D.
1958*a* *Neue Fossilfunde im Silur des Kellerwaldes.* Hessen, Landesamt Bodenf., Notizbl., vol. 86, pp. 111–118, text-figs. 1–4, (conodonts, pp. 111, 115, 116).
1958*b* *Das Oberdevon und Unterkarbon im südlichen Kellerwald.* Hessen, Landesamt Bodenf., Notizbl., vol. 87, pp. 89–119, 6 text-figs.

STOPPEL, D., and ZIEGLER, W.
1958 – *Zum Alter der "Buchenauer Schichten" bei Buchenau/Lahn (Rheinisches Schiefergebirge).* Hessen, Landesamt Bodenf., Notizbl., vol. 86, pp. 153–158, 1 text-fig.

STRASSBERG, M.
1954 – *Summary of the Stanolind Oil and Gas Company Walter Waswick No. 1 (well), Ward County, North Dakota.* North Dakota, Geol. Survey, Circular 68, 16 pp., (conodonts, p. 16).

STUBBLEFIELD, C. J., and CALVER, M. A.
1955 – *Palaeontology of the Coal Measures.* In: STEVENSON, I. P., and MITCHELL, G. H., with others, *Geology of the country between Burton upon Trent, Rugeley and Uttoxeter.* Great Britain, Geol. Survey, Mem., pp. 20–30, pl. 2, (conodonts, pp. 21, 25, 29).

STUMM, E. C., and WRIGHT, J. D.
1958 – *Check list of fossil invertebrates described from the Middle Devonian rocks of the Thedford-Arkona region of southwestern Ontario.* Michigan, Univ., Mus. Pal., Contr., vol. 14, no. 7, pp. 81–132, (conodonts, pp. 87, 96, 97, 111, 119).

SUMMERSON, C. H., and CAMPBELL, L. J.
1958 – *Holothurian sclerites from the Kendrick shale of eastern Kentucky.* Jour. Pal., vol. 32, no. 5, pp. 961–969, pls. 125–126, (conodonts, pp. 961, 962).

SWEET, W. C.
1954 – *Harding and Fremont formations, Colorado.* Amer. Assoc. Petr. Geol., Bull., vol. 38, no. 2, pp. 284–305, 4 text-figs., 2 tables. (Geol. Abstr., 1954, vol. 2, no. 1, p. 9.)
1955*a* *Cephalopods from the Fremont formation of central Colorado.* Jour. Pal., vol. 29, no. 1, pp. 71–82, pls. 16–18, 1 text-fig., (conodonts, p. 72). (Geol. Abstr., vol. 3, no. 1, p. 11.)
*1955*b* *Conodonts from the Harding formation (Middle Ordovician) of Colorado.* Jour. Pal., vol. 29, no. 2, pp. 226–262, pls. 27–29, 17 text-figs. (Geol. Abstr., 1955, vol. 3, no. 2, p. 17; Zentr. Geol. Pal., 1958, pt. 2, Jahrg. 1957, no. 5, p. 547.)

SYLVESTER-BRADLEY, P. C.
1954 – *Form-genera in paleontology.* Jour. Pal., vol. 28, no. 3, pp. 333–336. (Geol. Abstr., 1954, vol. 2, no. 3, p. 29; Biol. Abstr., 1955, vol. 29, pt. 2, p. 1520.)

TASCH, P.
1958 – *Significance of conodont control of pellet formation in the basal Maquoketa.* Micropaleontology, vol. 4, no. 2, pp. 187–191, 15 text-figs. (Geol. Abstr., vol. 6, no. 3, p. 87.)

TATGE, U.
*1956 – *Conodonten aus dem germanischen Muschelkalk, I. Teil.* Pal. Zeitschr., vol. 30, nos. 1–2, pp. 108–127, pls. 5–6, 12 text-figs., *II. Teil*, Ibid., nos. 3–4, pp. 129–147. (Micropaleontology, 1957, vol. 3, no. 4, p. 405; Bib. Geol. Excl. North Amer., 1958, vol. 21 (1956), p. 585.)

TEICHERT, C.
1958 – *Some biostratigraphic concepts.* Geol. Soc. Amer., Bull., vol. 69, pp. 99–120, (conodonts, p. 105).

TEICHMÜLLER, R., and ZIEGLER, W.
1957 – *Devonkalk-Gerölle im Zechsteinkonglomerat von Rossenray (Südwestlich Rheinberg/Niederrhein).* Neues Jahrb. Geol. Pal., Monatshefte, Jahrg. 1957, pp. 267–274, text-figs. 1–2. (Bib. Geol. Excl. North Amer., 1958, vol. 22 (1957), p. 538; Micropaleontology, 1958, vol. 4, no. 4, p. 437.)

TEIKE, M.
1956 – *Schichtenverzeichnis der Bohrung Weyer 1 bei Weyer im Oberlahnkreis (Lahnmulde, Hessen).* Hessen, Landesamt Bodenf., Notizbl., vol. 84, pp. 107–115. (Micropaleontology, 1957, vol. 3, no. 4, p. 405.)

THALMANN, H. E.
1955 – *Practical value of some microfossils.* Amer. Assoc. Petr. Geol., Bull., vol. 39, no. 7, pp. 1196–1201; also in: Jour. Pal., vol. 29, no. 4, pp. 727–731. (Jour. Sed. Petr., vol. 25, no. 2, pp. 127–128.)
1958 – *News reports: United States – West Coast.* Micropaleontology, vol. 4, no. 4, pp. 455–458, (conodonts, p. 455).

THOMAS, L. A.
1950 – *Sweetland Creek (Devonian) conodonts.* Jour. Pal., vol. 24, no. 4, pp. 497–498. (Biol. Abstr., 1950, vol. 24, pt. 3, p. 3273; Bib. North Amer. Geol. (1950), 1952, p. 258; Zentr. Geol. Pal., 1958, pt. 2, Jahrg. 1957, no. 5, p. 548.)

THOMAS, L. A., and BALSTER, C. A.
1949 – *Micropaleontological zones in Iowa.* Iowa Acad. Sci., Proc., vol. 56, pp. 235–240. (Bib. North Amer. Geol. (1950), 1952, p. 258.)

THOMPSON, M. L.
1953 – *News: North-Central United States.* The Micropaleontologist, vol. 7, no. 4, pp. 2–7, (conodonts, pp. 3–5).

THOMPSON, M. L., and KOTTLOWSKI, F. E.
1955 – *Pennsylvanian and Lower marine Permian stratigraphy of south-central New Mexico.* In: New Mexico Geological Society, Guidebook, 6th Annual Field Conference, South-Central New Mexico. 200 pp., (conodonts, p. 75).

THURSCH, H.
1958 – *Ein neues Verfahren zur Präparation von Kalkproben mit Essigsäure.* Neues. Jahrb. Geol. Pal., Monatshefte, Jahrg. 1958, pp. 283–284.

TJERNVIK, T. E.
1956 – *On the early Ordovician of Sweden, stratigraphy and fauna.* Uppsala, Geol. Inst., Bull., vol. 36, pt. 2–3, no. 6, pp. 107–284, (conodonts, p. 181). (Bib. Geol. Excl. North Amer., 1958, vol. 21 (1956), p. 598.)

TODD, R.
1952 – *News: United States – East Coast.* The Micropaleontologist, vol. 6, no. 1, pp. 2–4.
1953 – *News: Eastern United States.* The Micropaleontologist, vol. 7, no. 1, pp. 2–3.

TRAVES, D. M.
1955 – *The geology of the Ord-Victoria region, Northern Australia.* Australia, Bur. Min. Resources, Geol. and Geophysics, Bull. 27, 133 pp., 3 pls., 34 text-figs., 2 tables, maps, (conodonts, pp. 53, 55, 57).

TROMP, S. W.
1952 – *Tentative compilation of the micropaleontology of Egypt.* Jour. Pal., vol. 26, no. 4, pp. 661–667, (conodonts, p. 666).

TRUEMAN, A.
1954 – *Fossils of the Coal Measures and their use.* In: TRUEMAN, A. (Ed.), *The coalfields of Great Britain.* London; Edward Arnold, Ltd., (conodonts, pp. 60, 62, 187, text-fig. IV–3).

UNITED STATES GEOLOGICAL SURVEY
1952 – *Availability of U. S. Geological Survey technical files in paleontology.* Jour. Pal., vol. 26, no. 3, pp. 535–536.
1956 – *An addition to the available U. S. Geological Survey technical files in paleontology.* Jour. Pal., vol. 30, no. 1, pp. 220–221.

UPSHAW, C. F., TODD, R. G., and ALLEN, B. D.
1957 – *Fluoridization of microfossils.* Jour. Pal., vol. 31, no. 4, pp. 793–795, pl. 100. (Geol. Abstr., vol. 5, no. 3, p. 30.)

VERVILLE, G. J.
1958 – *Rock formations of Elk County* (abstracted by J. M. Jewett). In: VERVILLE, G. J., and others, *Geology, Mineral resources, and ground-water resources of Elk County, Kansas.* Kansas, Geol. Survey, Rept., vol. 14, 27 pp., 1 pl., 6 text-figs., (conodonts, pp. 15, 16).

WAERN, B.
1953 – *Paleontology and stratigraphy of the Cambrian and lowermost Ordovician of the Bödahamn core.* Uppsala, Geol. Inst., Bull., vol. 34, no. 9, pp. 223–250, 1 pl., 4 text-figs., (conodonts, pp. 232, 234, 236). (Bib. Geol. Excl. North Amer., vol. 19 – 1954, p. 510, 1955.)

WAGNER, H. C.
1954 – *Geology of the Fredonia quadrangle, Kansas.* U. S. Geol. Survey, Geol. Quadrangle Map GQ 49.

WAGNER, H. C., and HARRIS, L. D.
1953 – *Stratigraphy of the outcropping Pennsylvanian rocks of the Fredonia, quadrangle, Kansas.* U. S. Geol. Survey, Oil and Gas Invest. Chart OC 48.

WALDREN, C. H.
1955 – *Preliminary investigations of conodonts in the Winnipeg formation (Ordovician) of North Dakota.* North Dakota Acad. Sci., Proc., vol. 9, p. 17 (abstract).

WALLISER, O. H.
*1957 – *Conodonten aus dem oberen Gotlandium Deutschlands und der Karnischen Alpen.* Hessen, Landesamt Bodenf., Notizbl., vol. 85, pp. 28–52, pls. 1–3, 3 text-figs., 1 table.
1958*a* *Rhombocorniculum comleyense, n. gen., n. sp.* Pal. Zeitschr., vol. 32, no. 3–4, pp. 176–180, pl. 15.

1958*b* *Zum Oberdevon und Unterkarbon von Erdbach-Langenaubach (SW-Dillmulde, Rheinisches Schiefergebirge.* Hessen, Landesamt Bodenf., Notizbl., vol. 87, 1958, pp. 120–132, 3 text-figs., pl. 13.

WANLESS, H. R.
1957 – *Geology and mineral resources of the Beardstown, Glasford, Havana, and Vermont quadrangles.* Illinois, Geol. Survey, Bull. 82, 233 pp., 6 tables, 66 text-figs., 7 pls., (conodonts, pp. 56, 91, 104, 111, 116). (Geol. Abstr., vol. 5, no. 4, p. 98.)
1958 – *Pennsylvanian faunas of the Beardstown, Glasford, Havana, and Vermont quadrangles.* Illinois, Geol. Survey, Rept. Invest. 205, 59 pp., 4 tables, 2 text-figs., (conodonts, pp. 8, 22, 24, 26, 28–32, 50–53, table 3). (Geol. Abstr., vol. 6, no. 1, p. 126.)

WEISS, M. P.
1955 – *Some Ordovician brachiopods from Minnesota and their stratigraphic relations.* Jour. Pal., vol. 29, no. 5, pp. 759–774, pls. 69–72, (conodonts, pp. 760–763, 765). (Geol. Abstr., vol. 3, no. 4, p. 50.)

WELLER, J. M.
1957 – *Paleoecology of the Pennsylvanian period in Illinois and adjacent states.* In: LADD, H. S. (ed.), *Treatise on marine ecology and paleoecology.* Geol. Soc. Amer., Mem. 67, pp. 325–364, (conodonts, p. 351).

WERNER, C., and ECHOLS, D. J.
1958 – *Three dimensional graptolites in the Maquoketa shale (Upper Ordovician) of Missouri.* Jour. Pal., vol. 32, no. 5, pp. 1026–1029, 3 text-figs.

WEST TEXAS GEOLOGICAL SOCIETY
1952 – *Guidebook, 1952 Spring field trip, Marathon Basin, Brewster and Pecos Counties, Trans-Pecos Texas.* Midland; West Texas Geol. Soc., 78 pp., 53 text-figs., (conodonts, pp. 23, 46, 47, 65–66).

WIEGEL, E.
1956 – *Sedimentation und Tektonik im Westteil der Galgenberg-Mulde.* Hessen, Landesamt Bodenf., Abh., no. 15, 156 pp., 41 text-figs., 7 tables, 7 pls., (conodonts, pp. 41, 45, 50, 65–66). (Bib. Geol. Excl. North Amer., 1958, vol. 21 (1956), p. 642.)

WILLIAMS, H. L.
1953 – *Resume of west Texas Permian invertebrate fossils.* In: JONES, T. S., *Stratigraphy of the Permian basin of west Texas.* Midland; West Texas Geol. Soc., pp. 58–63, (conodonts, p. 59).
1958*a* *Barnett shale.* In: FILLMAN, L. (Chm.), *Lexicon of pre-Pennsylvanian stratigraphic names of west Texas and southeastern New Mexico.* Midland; West Texas Geol. Soc., pp. 14–17, (conodonts, p. 16).
1958*b* *Doublehorn shale member.* In: FILLMAN, L. (Chm.), *Lexicon of pre-Pennsylvanian stratigraphic names of west Texas and southeastern New Mexico.* Midland; West Texas Geol. Soc., pp. 44–45.
1958*c* *Houy formation.* In: FILLMAN, L. (Chm.), *Lexicon of pre-Pennsylvanian stratigraphic names of west Texas and southeastern New Mexico.* Midland; West Texas Geol. Soc., pp. 64–65.
1958*d* *Ives Breccia.* In: FILLMAN, L. (Chm.), *Lexicon of pre-Pennsylvanian stratigraphic names of west Texas and southeastern New Mexico.* Midland; West Texas Geol. Soc., pp. 67–68.

WILLIAMS, J. S.
1957 – *Paleoecology of the Mississippian of the upper Mississippi valley region.* In: LADD, H. S. (Ed.), *Treatise on marine ecology and paleoecology.* Geol. Soc. Amer., Mem. 67, pp. 279–324, (conodonts, pp. 279, 290, 291, 292, 294, 295, 297, 298, 303, 306, 311, 314).

WILSON, A. E.
1947 – *The Algae, Spongiae, Anthozoa, Stromatoporidea, Graptolitoidea, Vermes, conodonts, and trails of the Ottawa formation within the Ottawa-St. Lawrence lowland.* Royal Soc. Canada, Proc., 3rd series, vol. 41, p. 192 (abstract). These are scolecodonts not conodonts (written communication, Fay, R. O.).

WILSON, L. R.
1958 – *Oklahoma's oldest fossil trees.* Oklahoma, Geol. Survey, Geol. Notes, vol. 18, no. 11, pp. 172–177, 4 pls., (conodonts, p. 176).

WOODLAND, A. W., ARCHER, A. A., EVANS, W. B., and CALVER, M. A.
1957 – *Recent boreholes into the Lower Coal Measures below the Gellideglower Pumpquart coal horizon in South Wales.* Great Britain, Geol. Survey, Bull. 13, pp. 39–60, pl. 4, 2 text-figs., (conodonts, p. 46). (Bib. Geol. Excl. North Amer., 1958, vol. 22 (1957), p. 597.)

WURM, A.
1956 – *Neue Ergebnisse der Forschungen im variskischen Gebirge Nordostbayerns.* Deutsch. Geol. Ges. Zeitschr., vol. 108, Jahrg. 1956, pt. 1, pp. 6–20, 3 text-figs., (conodonts, pp. 8, 10).
1957 – *Exkursionen in den Frankenwald und das Fichtelgebirge.* Deutsch. Geol. Ges. Zeitschr. vol. 108, Jahrg. 1956, pt. 2, pp. 270–306, 12 text-figs., 2 tables, (conodonts, pp. 280, 281, 283).

YOUNGQUIST, W. L.
1952 – *Triassic conodonts from southeastern Idaho.* Jour. Pal., vol. 26, no. 4, pp. 650–655. (Zentr. Geol. Pal., 1958, pt. 2, Jahrg. 1957, no. 5, p. 549.)

YOUNGQUIST, W. L., and DOWNS, H. R.
1951 – *Conodonts from the Lower Mississippian Wassonville dolomite of Iowa.* Jour. Pal., vol. 25, no. 6, pp. 785–792, pl. 111. (Biol. Abstr., 1952, vol. 26, p. 3244; Zentr. Geol. Pal., 1958, pt. 2, Jahrg. 1957, no. 5, p. 549.)

YOUNGQUIST, W. L., HAWLEY, R. W., and MILLER, A. K.
*1951 – *Phosphoria conodonts from southeastern Idaho.* Jour. Pal., vol. 25, no. 3, pp. 356–364, pl. 54. (Biol. Abstr., 1951, vol. 25, p. 3125; Zentr. Geol. Pal., 1958, pt. 2, Jahrg. 1957, no. 5, pp. 549–550.)

YOUNGQUIST, W. L., and IGLESIAS, S. J.
1951 – *Ordovician conodonts from South America.* Jour. Pal., vol. 25, no. 3, p. 408. (Biol. Abstr., 1951, vol. 25, p. 3125; Zentr. Geol. Pal., 1958, pt. 2, Jahrg. 1957, no. 5, p. 550.)

YOUNGQUIST, W. L., and MILLER, A. K.
*1949 – *Conodonts from the Late Mississippian Pella beds of south-central Iowa.* Jour. Pal., vol. 23, no. 6, pp. 617–622, pl. 101. (Biol. Abstr., 1950, vol. 24, p. 2410; Zentr. Geol. Pal., 1952, pt. 2, Jahrg. 1951, pp. 63–64.)

YOUNGQUIST, W. L., MILLER, A. K., and DOWNS, H. R.
1950 – *Burlington conodonts from Iowa.* Jour. Pal., vol. 24, no. 5, pp. 525–530, pl. 67. (Biol. Abstr., 1951, vol. 25, p. 896; Bib. North Amer. Geol. (1950), 1952, p. 289; Zentr. Geol. Pal., 1958, pt. 2, Jahrg. 1957, no. 5, p. 550.)

ZANGERL, R. and RICHARDSON, E. S., JR.
1955 – *Ecologic history of a transgressing Pennsylvanian sea near Mecca, Indiana (preliminary report).* Geol. Soc. Amer., Bull., vol. 66, no. 12, pt. 2, p. 1639.

ZAPP, A. D.
1957 – *No. 9, White River uplift measured section.* In: MCKEE, E. D. (Ed.), *Colorado measured sections, a symposium.* Denver; Rocky Mountain Assoc. Geol., pp. 46–49, measured section strip no. 9.

ZIEGLER, W.
*1956 – *Unterdevonische conodonten, insbesondere aus dem Schönauer und dem Zorgensiskalk.* Hessen, Landesamt Bodenf., Notizbl., vol. 84, pp. 93–106, pls. 6–7, 1 table. (Micropaleontology, 1957, vol. 3, no. 4, p. 406; Zentr. Geol. Pal., 1958, pt. 2, Jahrg. 1957, no. 5, pp. 550–551.)
1957 – *Das Marburger Gotlandium.* Hessen, Landesamt Bodenf., vol. 85, pp. 67–74, 4 text-figs., (conodonts, pp. 68, 72). (Micropaleontology, 1958, vol. 4, no. 4, p. 438.)
1958*a* *Ein Devon-Karbonprofil westlich von Marburg/Lahn. Stratigraphic und Tektonik.* Hessen, Landesamt Bodenf., Notizbl., vol. 86, pp. 119–132, 4 text-figs., (conodonts, pp. 124, 126, 127).
*1958*b* – *Conodontenfeinstratigraphische Untersuchungen an der Grenze Mitteldevon/Oberdevon und in der Adorfstufe.* Hessen, Landesamt Bodenf., Notizbl., vol. 87, pp. 7–77, pls. 1–12, 7 text-figs., 10 tables.

THESES AND DISSERTATIONS

ACHAUER, C.
1957 – *Stratigraphy and microfossil studies of the Sappington formation, southwestern Montana.* Master's thesis, Montana State Univ.

BIESIOT, P. G.
1950 – *Conodonts and fish remains in the Missouri series of Nebraska.* Master's thesis, Univ. of Nebraska.

BISCHOFF, G.
1956 – *Conodonten um die Wende Mitteldevon/Oberdevon und Oberdevon/Unterkarbon.* Doctoral dissertation, Philipps Universität, Marburg.

BJORAKER, R. W.
1955 – *Upper Devonian conodonts from the Lime Creek formation of northern Iowa.* Master's thesis, State Univ. of Iowa.

CHAMBLIN, W. J.
1956 – *Pennsylvanian conodont faunas from Iowa.* Master's thesis, Univ. of Illinois.

COHENOUR, R. E.
1957 – *Geology of the Sheeprock mountains, Tooele and Juab Counties, Utah.* Doctoral dissertation, Univ. of Utah. (Dissertation Abstr., vol. 18, p. 1013.) To be published by the Utah Geol. and Min. Survey.

COLSON, W. E.
1943 – *A new Mississippian conodont fauna from Kentucky.* Master's thesis, Univ. of Missouri.

DOWNS, R, H.
1947 – *Some Pennsylvanian conodonts from Iowa.* Master's thesis, State Univ. of Iowa.

DRAKE, D. A.
1958 – *Microfauna of the Cisco series, Brown and Coleman Counties, Texas.* Master's thesis, Univ. of Texas.

EARLY, A. K.
1951 – *Microfauna of the Brownwood shale, Brown and McCulloch Counties, Texas.* Master's thesis, Univ. of Texas.

EICHER, D. B.
1939 – *Conodonts from the Elmhurst quarry fissure fillings.* Master's thesis, Univ. of Chicago.

ETHINGTON, R. L.
1958 – *Conodonts of the Galena formation.* Doctoral dissertation, State Univ. of Iowa. (Dissertation Abstr., vol. 18, p. 513.)

GATCHELL, J. H.
1948 – *The conodonts of the lower Joins of Oklahoma.* Master's thesis, Univ. of Missouri.

GLEIM, D. T.
1955 – *Stratigraphy and paleontology of the Lower Pennsylvanian rocks in southeastern Iowa.* Doctoral dissertation, State Univ. of Iowa. (Dissertation Abstr., vol. 15, p. 1596.)

GRAVES, R. W.
1949 – *Geology of Hood Spring quadrangle, Brewster County, Texas.* Doctoral dissertation, Univ. of Texas.

HALLER, C. R.
1957 – *Devonian – Mississippian boundary relationships in central Missouri.* Master's thesis, Univ. of Missouri.

HAWLEY, R. W.
1950 – *Phosphoria conodonts from southeastern Idaho.* Master's thesis, Univ. of Idaho. Published in: Jour. Pal., 1951, vol. 25, no. 3, pp. 356–364.

HAZEL, H. F.
1955 – *The conodont fauna of the basal Clarksville member of the Waynesville formation.* Master's thesis, Miami Univ. (Ohio).

JOHNSON, C. M.
1957 – *Conodonts of the "Passo Beds", Missouri.* Master's thesis, Univ. of Missouri.

KASTLER, N. B.
1958 – *Conodonts from Middle Pennsylvanian of southeastern Iowa.* Master's thesis, State Univ. of Iowa.

KLAUSING, R.
1957 – *Basal Marmaton conodonts from Missouri.* Master's thesis, Univ. of Missouri.

KRETSCH, D. L.
1955 – *Conodonts from near the Devonian – Mississippian boundary of southern Indiana.* Master's thesis, Univ. of Missouri.

MENDENHALL, M. E.
1951 – *Conodonts and fish remains of the Douglas and Shawnee groups of the Virgil series of Nebraska.* Master's thesis, Univ. of Nebraska.

NIEWOEHNER, W. B.
1955 – *Devonian – Mississippian boundary formations, Missouri.* Master's thesis, Univ. of Missouri.

PARCHMAN, W.
1955 – *Conodonts of the Marmaton group in south-central Iowa.* Master's thesis, Univ. of Wisconsin.

PATTERSON, S. H.
1947 – *Conodonts from the Prospect Hill member of the Hannibal formation.* Master's thesis, State Univ. of Iowa.

PERRY, N.
1957 – *Ontogenetic study of some Upper Devonian Polygnathids.* Master's thesis, Univ. of Missouri.

POLLACK, J. M.
1951 – *A faunal study of the Harding sandstone in the Canon City embayment, Colorado.* Master's thesis, Univ. of Oklahoma.

REXROAD, C. B.
1955 – *Conodonts from the type Chester, Illinois.* Doctoral dissertation, State Univ. of Iowa. (Dissertation Abstr., vol. 15, p. 2167.) Published in: Illinois, Geol. Survey, Rept. Invest. 199, 1957.

SMOOT, V.
1958 – *The age and correlation of isolated black shale outcrops in southeastern Missouri, based on conodont evidence.* Master's thesis, Univ. of Missouri.

STEVENSON, W. L.
1955 – *Pennsylvanian conodonts of Illinois.* Master's thesis, Univ. of Illinois.

STANLEY, E. A.
1956 – *Some Mississippian conodonts from the High Resistivity shale of the Nancy Watson no. 1 well in northeastern Mississippi.* Master's thesis, Pennsylvania State Univ. Published in: Jour. Pal., 1958, vol. 32, no. 3, pp. 459–476.

STONE, G. L.
1957 – *Bighorn conodonts from Wyoming.* Master's thesis, State Univ. of Iowa.

SWEET, W. C.
1954 – *The Harding and Fremont formations of Colorado and their faunas.* Doctoral dissertation, State Univ. of Iowa.

TATGE, U.
1956 – *Der Momberger Graben und Conodonten aus dem germanischen Muschelkalk.* Inauguraldissertation zur Erlangen des Doktorgrades der Philosophischen Fakultät der Philipps-Universität zu Marburg.

TRELOAR, A. M.
1957 – *The conodonts of the Ordovician Maquoketa formation in Iowa.* Master's thesis, State Univ. of Iowa. Published in: Jour. Pal., 1957, vol. 31, no. 4, pp. 715–736.

TURCO, C. A.
1957 – *The conodont fauna of the Upper Ordovician Southgate member, southwestern Ohio.* Master's thesis, Ohio State Univ.

VERVILLE, G. J.
1951 – *Pennsylvanian and Permian stratigraphy of Elk County, Kansas.* Doctoral dissertation, Univ. of Wisconsin.

WARNER, E.
1956 – *The conodont fauna of the Upper Ordovician Economy member, southwestern Ohio.* Master's thesis, Ohio State Univ.

WILKIE, L. C.
1957 – *The conodont faunas of the Upper Ordovician McMicken member, southwestern Ohio.* Master's thesis, Ohio State Univ.

WOODS, E. K.
1955 – *Some Devonian and Mississippian conodonts from northern Arkansas.* Master's thesis, Univ. of Missouri.

ZALUSKY, D. W.
1958 – *Conodonts of the Holts Summet (late Devonian) of central Missouri.* Master's thesis, Univ. of Missouri.

INDEX TO CONODONTS

The new forms of conodonts proposed in the published articles cited in the bibliography are listed here. Included in the alphabetically arranged list are: 1 new superfamily, 2 new families, 38 new genera, 3 new subgenera, 418 new species, 7 new subspecies, and 16 new varieties of disjunct units (form genera of some authors), and 3 new genera and 3 new species of assemblages.

DISJUNCT UNITS

Acodus deltatus Lindström, 1954, p. 544, pl. 3, fig. 30. Lower Ordovician, Sweden.

A. deltatus var. *altior* Lindström, 1954, p. 544, pl. 3, figs. 27–29. Lower Ordovician, Sweden.

A. gladiatus Lindström, 1954, pp. 544–545, pl. 3, figs. 10–12. Lower Ordovician, Sweden.

A. gratus Lindström, 1954, p. 545, pl. 2, figs. 27–29. Lower Ordovician, Sweden.

A. pulcher Lindström, 1954, p. 546, pl. 2, fig. 38. Lower Ordovician, Sweden.

A. similaris Rhodes, 1955, pp. 124–125, pl. 10, figs. 7, 10, 14, 16, 18, 23, 26–28, 30. Upper Ordovician, England.

A. tetrahedron Lindström, 1954, p. 546, pl. 4, figs. 1–2. Lower Ordovician, Sweden.

Acontiodus angustus Sannemann, 1955c, pp. 24–25, pl. 2, fig. 7, Ordovician, Germany.

A. arcuatus Lindström, 1954, pp. 547–548, pl. 2, figs. 1–4, text-fig. 3A. Lower Ordovician, Sweden.

A. franconicus Sannemann, 1955c, pp. 23–24, pl. 1, figs. 1–6. Ordovician, Germany.

A. reclinatus Lindström, 1954, pp. 548–549, pl. 2, figs. 5–6, text-fig. 3C. Lower Ordovician, Sweden.

A. rectus Lindström, 1954, p. 549, pl. 2, figs. 7–11, text-figs. 2 k–m, 3B. Lower Ordovician, Sweden.

A. rectus var. *sulcatus* Lindström, 1954, p. 550, pl. 2, figs. 12–13, text-fig. 3D. Lower Ordovician, Sweden.

A. recurvatus Sannemann, 1955c, p. 24, pl. 1, figs. 9–11. Ordovician, Germany.

Ambalodus elegans Rhodes, 1953b, p. 278–279, pl. 20, figs. 21–25. Upper Ordovician, England.

A. pulcher Rhodes, 1953b, p. 279, pl. 20, figs. 38–41. Upper Ordovician, England.

A. robustus Rhodes, 1953b, pp. 279–280, pl. 20, figs. 26, 27, 32, 33. Upper Ordovician, England.

A. triangularis var. *indentatus* Rhodes, 1953b, pp. 280–281, pl. 20, figs, 35–37, 56. Upper Ordovician, England.

Amorphognathus aduncа Glenister, 1957, p. 723, pl. 88, figs. 23, 24. Upper Ordovician, Iowa.
A. complicatus Rhodes, 1953b, p. 282, pl. 20, figs. 42, 45, 46. Upper Ordovician, England.
A. duftonus Rhodes, 1955, pp. 123–124, pl. 9, figs. 1, 3, 5, 8. Upper Ordovician, England.
A. inaequalis Rhodes, 1953b, pp. 283–284, pl. 22, fig. 204. Middle Ordovician, England.
A. lingualis Sweet, 1955b, pp. 248–249, pl. 29, fig. 24. Middle Ordovician, Colorado.
A. tridigitata Glenister, 1957, p. 724, pl. 88, fig. 22. Upper Ordovician, Iowa.
Ancyrodella ioides Ziegler, 1958b, pp. 42–43, pl. 11, figs. 2–4. Upper Devonian, Germany.
Ancyrodelloides Bischoff and Sannemann, 1958, pp. 91–92; *Ancyrodelloides trigonica* Bischoff and Sannemann, 1958. Lower Devonian.
A. kutscheri Bischoff and Sannemann, 1958, pp. 93–94, pl. 12, figs. 15, 17–18. Lower Devonian, Germany.
A. trigonica Bischoff and Sannemann, 1958, pp. 92–93, pl. 12, figs. 9, 12–14, 16. Lower Devonian, Germany.
Ancyrognathus alta Müller and Müller, 1957, pp. 1094–1095, pl. 138, figs. 4a–4c. Upper Devonian, Iowa.
A. amana Müller and Müller, 1957, p. 1095, pl. 138, figs. 5a, 5b. Upper Devonian, Iowa.
Ancyropenta Müller and Müller, 1957, pp. 1092–1093; *Ancyrognathus curvata* Branson and Mehl, 1934; p. 241, pl. 19, figs. 6, 11. Upper Devonian.
A. longidenticulata Müller and Müller, 1957, p. 1093, pl. 136, figs. 3a–3c, pl. 137, figs. 1a, 1b, 2. Upper Devonian, Iowa.
Angulodus bidentatus Sannemann, 1955b, p. 127, pl. 3, fig. 18. Upper Devonian, Germany.
A. bockae Tatge, 1956, pp. 129–130, pl. 5, figs. 1–5. Middle Triassic, Germany.
A.? prioniodellides Tatge, 1956, p. 130, pl. 5, fig. 6. Middle Triassic, Germany.
Apatognathus inversus Sannemann, 1955b, p. 127, pl. 6, figs. 18a–18c. Upper Devonian, Germany.
A. lipperti Bischoff, 1956, pp. 121–122, pl. 9, figs. 27, 31. Upper Devonian, Germany.
A. longidentatus Tatge, 1956, pp. 130–131, pl. 5, figs. 18–19. Middle Triassic, Germany.
A. ziegleri Diebel, 1956b, p. 433, pl. 5, figs. 1–2. Upper Cretaceous, Cameroons.
Aphelognathus Branson, Mehl and Branson, 1951, p. 9; *Aphelognathus grandis* Branson, Mehl and Branson, 1951. Upper Ordovician.
A. acutidentata Branson, Mehl and Branson, 1951, pp. 9–10, pl. 2, figs. 15, 16. Upper Ordovician, Kentucky.
A. elegantus Rhodes, 1955, p. 128, pl. 8, figs. 17–18. Upper Ordovician, England.
A. grandis Branson, Mehl and Branson, 1951, p. 9, pl. 2, figs. 11–14. Upper Ordovician, Kentucky and Indiana.
Avignathus Lys, Serre and Deroo, 1957, pp. 797–798; *Avignathus beckmanni* Lys, Serre and Deroo, 1957. Upper Devonian.
A. beckmanni Lys, Serre and Deroo, 1957, p. 798, text-figs. 2a–2b. Upper Devonian, France.
A. orthoptera Ziegler, 1958b, pp. 51–52, pl. 12, figs. 13–14. Upper Devonian, Germany.

Balognathus Rhodes, 1953b, p. 284; *Balognathus expansus* Rhodes, 1953b. Upper Ordovician.
B. expansus Rhodes, 1953b, p. 285, pl. 20, figs. 50–53, 57. Upper Ordovician, England.
Belodus dispansus Glenister, 1957, p. 729–730, pl. 88, figs. 14, 15. Upper Ordovician, Iowa.
B. erectus Rhodes and Dineley, 1957, p. 359, pl. 38, fig. 8. Middle(?) Devonian, England.
Bryantodus alternatus Bischoff and Ziegler, 1957, pp. 45–46, pl. 19, figs. 40, 46. Middle Devonian, Germany.
B. angustus Bischoff and Ziegler, 1957, pp. 46–47, pl. 13, fig. 6. Middle Devonian, Germany.
B. biculminatus Bischoff and Ziegler, 1957, p. 47, pl. 13, figs. 7, 8a, 8b, 9. Middle Devonian, Germany.
B. grandis Bischoff and Ziegler, 1957, pp. 48–49, pl. 20, figs. 21, 22, 25, 26. Middle Devonian, Germany.
B. paeckelmanni Bischoff and Ziegler, 1957, pp. 50–51, pl. 18, figs. 1a, 1b, 2–7. Middle Devonian, Germany.
B. solidus Stewart and Sweet, 1956, pp. 265–266, pl. 34, fig. 8. Middle Devonian, Ohio.

Cavusgnathus characta Rexroad, 1957, pp. 15–16, pl. 1, figs. 1, 2. Upper Mississippian, Illinois.
C. convexa Rexroad, 1957, p. 17, pl. 1, figs. 3–6. Upper Mississippian, Illinois.
C. cristata var. *grandis* Elias, 1956, p. 115, pl. 2, Figs. 12–14. Middle Mississippian, Oklahoma.
C. regularis Youngquist and Miller, 1949, p. 619, pl. 101, figs. 24, 25. Upper Mississippian, Iowa.
C. unicornis Youngquist and Miller, 1949, p. 619, pl. 101, figs. 18–23. Upper Mississippian, Iowa.
Chirognathus cultidactyla Sweet, 1955b, pp. 236–237, pl. 27, fig. 11. Middle Ordovician, Colorado.
Cordylodus? dubius Rhodes, 1953b, p. 299, pl. 23, figs. 221–224. Upper Silurian, England.
C. elongatus Rhodes, 1953b, pp. 299–300, pl. 21, figs. 114–118. Upper Ordovician, England.
C. geniculatus Rhodes, 1953b, p. 300, pl. 21, fig. 113. Upper Ordovician, England.
C. perlongus Lindström, 1954, p. 552, pl. 6, figs. 36, 37. Lower Ordovician, Sweden.
C. prion Lindström, 1954, pp. 552–553, pl. 5, figs. 14–16. Lower Ordovician, Sweden.
Ctenognathus conservativa Müller, 1956a, p. 821, pl. 95, figs. 25–27. Lower Triassic, Nevada.
C. discreta Müller, 1956a, pp. 821–822, pl. 95, figs. 24, 28. Lower Triassic, Nevada.
C. (Pandorinellina) Müller and Müller, 1957, pp. 1082–1083; *Pandorina insita* Stauffer, 1940. Range not given.
Ctenopolygnathus Müller and Müller, 1957, p. 1084; *Polygnathus angustidisca* Youngquist, 1945, p. 365, pl. 54, fig. 2. Upper Devonian–Lower Mississippian.

Distacodus peracutus Lindström, 1954, pp. 555–556, pl. 3, figs. 1–2, text fig. 5d. Lower Ordovician, Sweden.
D. rhombicus Lindström, 1954, p. 556, pl. 3, figs. 35–36. Lower Ordovician, Sweden.
D. stola Lindström, 1954, pp. 556–557, pl. 3, figs. 43–49. Lower Ordovician, Sweden.
D. stola var. *latus* Lindström, 1954, p. 557, pl. 3, figs, 50, 51. Lower Ordovician, Sweden.
Distomodus curvatus Rhodes, 1953b, pp. 290–291, pl. 23, figs. 209, 226–228. Upper Silurian, England.
D. curvatus var. *dentatus* Rhodes, 1953b, p. 291, pl. 23, figs. 217, 218, 229, 230. Upper Silurian, England.
D. suberectus Rhodes, 1953b, p. 290, pl. 23, figs. 207, 208, 210, 211. Upper Silurian, England.
Drepanodus altipes Henningsmoen, 1948, p. 420, pl. 25, fig. 14. Upper Ordovician, Sweden.

D. amoenus Lindström, 1954, p. 558, pl. 2, figs. 25, 26, text-fig. 4b. Lower Ordovician, Sweden.
D. conulatus Lindström, 1954, p. 561, pl. 2, fig. 34, pl. 4,fig. 34. Lower Ordovician, Sweden.
D. crassus Sannemann, 1955c, p. 26, pl. 1, figs. 20–21. Ordovician, Germany.
D. cyranoicus Lindström, 1954, pp. 561–562, pl. 5, fig. 8. Lower Ordovician, Sweden.
D. deltifer Lindström, 1954, p. 562, pl. 2, figs. 42–43. Lower Ordovician, Sweden.
D. herrmanni Ziegler, 1956, pp. 99–100, pl. 7, fig. 27. Lower Devonian, Germany.
D. latus Lindström, 1954, p. 564, pl. 3, figs. 22, 23. Lower Ordovician, Sweden.
D. longibasis Lindström, 1954, p. 564, pl. 3, fig. 31. Lower Ordovician, Sweden.
D. numarcuatus Lindström, 1954, pp. 564–565, pl. 2, figs. 48, 49, text-fig. 31. Lower Ordovician, Sweden.
D. planus Lindström, 1954, pp. 565–566, pl. 2, figs. 35–37, text-fig. 4a. Lower Ordovician, Sweden.
D. proteus Lindström, 1954, p. 566, pl. 3, figs. 18–21, text-figs. 2a–2f, 2j. Lower Ordovician, Sweden.
D. sculponea Lindström, 1954, p. 657, pl. 2, fig. 40, text-fig. 3L. Lower Ordovician, Sweden.
D. similaris Rhodes, 1953b, pp. 292–293, pl. 21, figs. 97–99. Upper Ordovician, England.

Ellisonia Müller, 1956a, p. 822; *Ellisonia triassica* Müller, 1956. Upper Devonian to Middle Triassic.
E. nevadensis Müller, 1956a, p. 822, pl. 96, figs. 15, 16. Lower Triassic, Nevada.
E. triassica Müller, 1956a, p. 822, pl. 96, figs. 12–14. Lower Triassic, Nevada.
Eoligonodina Branson, Mehl and Branson, 1951, pp. 14–15; *Eoligonodina robusta* Branson, Mehl and Branson, 1951. Upper Ordovician.
E. richmondensis Branson, Mehl and Branson, 1951, p. 15, pl. 4, figs. 23–27. Upper Ordovician, Kentucky.
E. robusta Branson, Mehl and Branson, 1951, p. 15, pl. 4, figs. 33, 35–37. Upper Ordovician, Kentucky and Indiana.

Falcodus aculeatus Sannemann, 1955b, p. 128, pl. 6, fig. 14. Upper Devonian, Germany.
F. guntharii Ziegler, 1958b, pp. 52–53, pl. 12, figs. 4–7. Upper Devonian, Germany.
F. variabilis Sannemann, 1955b, p. 129, pl. 4, figs. 1–4. Upper Devonian, Germany.
Falodus Lindström, 1954, p. 568; *Oistodus prodentatus* Graves and Ellison, 1941, p. 13, pl. 2, figs. 6, 22, 23, 28. Lower to Middle Ordovician.

Geniculatus Hass, 1953a, p. 77; *Polygnathus? claviger* Roundy, 1926, p. 14, pl. 4, figs. 1a–1c, 2a–2b. Mississippian.
G. longiden Elias, 1956, p. 121, pl. 4, figs. 27–29. Upper Mississippian, Oklahoma.
Gnamptognathus Ziegler, 1958b, pp. 53–54; *Gnamptognathus walliseri* Ziegler, 1958b. Upper Devonian.
G. walliseri Ziegler, 1958b, pp. 54–55, pl. 12, figs. 15, 16, 18, 19, 20, 23. Upper Devonian, Germany.
Gnathodus bilineatus semiglaber Bischoff, 1957, p. 22, pl. 3, figs. 1a, 1b, 2–10, 12, 14. Middle and Upper Mississippian, Germany.
G. commutatus nodosus Bischoff, 1957, pp. 23–24, pl. 4, figs. 12–13. Upper Mississippian, Germany.
G. commutatus punctatus Bischoff, 1957, p. 24, pl. 4, figs. 7–11, 14. Middle and Upper Mississippian, Germany.
G. girtyi Hass, 1953a, p. 80, pl. 14, figs. 22–24. Middle and Upper Mississippian, Texas.
G. glaber Elias, 1956, pp. 118–119, pl. 3, figs. 46–48. Upper Mississippian, Oklahoma.
G. inornatus Hass, 1953a, p. 80, pl. 14, figs. 9–11. Middle and Upper Mississippian, Texas.
G. kockeli Bischoff, 1957, p. 25, pl. 3, figs. 27a, 27b, 28–32. Lower Mississippian, Germany.
G. liratus Youngquist and Miller, 1949, pp. 619–620. pl. 101, figs. 15–17. Upper Mississippian, Iowa.
G. modocensis Rexroad, 1957, pp. 30–31, pl. 1, figs. 15–17. Upper Mississippian, Illinois.
G. multilineatus Elias, 1956, p. 119, pl. 3, figs. 49–53. Upper Mississippian, Oklahoma.
G. pretexanus Elias, 1956, pp. 115–116, pl. 3, figs. 9–11. Middle Mississippian, Oklahoma.
G. streptognathoides Elias, 1956, p. 119, pl. 3, figs. 54–57. Upper Mississippian, Oklahoma.
Gondolella eotriassica Müller, 1956a, pp. 823–824, pl. 95, figs. 10, 11. Lower Triassic, Nevada.
G. haslachensis Tatge, 1956, pp. 131–132, pl. 6, fig. 3. Middle Triassic, Germany.
G. idahoensis Youngquist, Hawley and Miller, 1951, p. 361, pl. 54, figs. 1–3, 14, 15. Middle Permian, Idaho.
G. milleri Müller, 1956a, p. 823, pl. 95, figs. 1–9. Lower Triassic, Nevada.
G. mombergensis Tatge, 1956, p. 132, pl. 6, figs. 1–2. Middle Triassic, Germany.
G. navicula Huckriede, 1958, pp. 147–148, pl. 11, figs. 1–4, 13–19, 27, 35, pl. 12, figs. 2–8, 10, 15–22, 24–27. Upper Triassic, Austria.
G. phosphoriensis Youngquist, Hawley and Miller, 1951, p. 362, pl. 54, figs. 10–12, 27, 28. Middle Permian, Idaho.
G. prima Elias, 1956, p. 120, pl. 4, fig. 3. Middle Mississippian, Oklahoma.
Gothodus Lindström, 1954, p. 569; *Gothodus costulatus* Lindström, 1954. Lower Ordovician.
G. costulatus Lindström, 1954, p. 569, pl. 5, figs. 23–25. Lower Ordovician, Sweden.
Gyrognathus elongatus Rhodes, 1953b, pp. 318–319, pl. 22, figs. 201, 202, 205, 206. Middle Ordovician, England.
G.? superbus Rhodes, 1953b, p. 319, pl. 21, fig. 132. Upper Ordovician, England.

Hamulosodina bransoni Elias, 1956, p. 108, pl. 1, fig. 4. Upper Mississippian, Oklahoma.
H. brevis Elias, 1956, p. 109, pl. 1, figs. 30–31. Upper Mississippian.
H. cooperi Elias, 1956, p. 109, pl. 1, figs. 28–29. Upper Mississippian, Oklahoma.
H. hassi Elias, 1956, p. 108, pl. 1, figs. 11–12. Middle Mississippian, Oklahoma.
H. scotti Elias, 1956, p. 109 and Scott, 1942, p. 299, pl. 40, fig. 16. Upper Mississippian, Montana.
Hibbardella milleri Rexroad, 1958, p. 18, pl. 2, figs. 13–16. Upper Mississippian, Illinois, Indiana and Kentucky.
H. ortha Rexroad, 1958, pp. 18–19, pl. 2, figs. 9–12. Upper Mississippian, Illinois, Indiana and Kentucky.
H. subsymmetrica Müller, 1956a, pp. 825–826, pl. 96, fig. 11. Lower Triassic, Nevada.
HIBBARDELLIDAE Müller, 1956a, p. 824. A new family which includes the following genera: *Hibbardella* Ulrich and Bassler, 1925; *Trichonodella* Branson and Mehl, 1948; *Diplododella* Ulrich and Bassler, 1925; *Elsonella* Youngquist, 1945; *Roundya* Hass, 1953; *Tripodellus* Sannemann, 1955; and *Ellisonia* Müller, 1956a.

Hindeodella adunca Bischoff and Ziegler, 1957, pp. 57–58, pl. 7, figs. 11–13, Middle Devonian, Germany.
H. bigeniculata Elias, 1956, p. 106, pl. 1, figs. 16?, 20, 21. Upper Mississippian, Oklahoma.
H. ensis Hass, 1953a, pp. 81–82, pl. 16, figs. 19–21. Middle and Upper Mississippian, Texas.
H. equidentata Rhodes, 1953b, p. 303, pl. 23, figs. 248, 252–254. Upper Silurian, England.
H. ibergensis Bischoff, 1957, p. 28, pl. 6, figs. 33, 37, 39. Middle and Upper Mississippian, Germany.
H. longissima Elias, 1956, pp. 106–108, pl. 1, figs. 32–35. Upper Mississippian, Oklahoma.
H. mehli Elias, 1956, p. 108, pl. 1, figs. 22–24. Upper Mississippian, Oklahoma.
H. multihamata Huckriede, 1958, pp. 148–149, pl. 10, figs. 52, 53, pl. 12, fig. 23. Middle Triassic, Austria.
H. nevadensis Müller, 1956a, p. 826, pl. 96, figs. 2–3. Lower Triassic, Nevada.
H. pachymandala Stanley, 1958, p. 466, pl. 63, fig. 5. Upper Mississippian, Mississippi.
H. petrae-viridis Huckriede, 1958, pp. 149–150, pl. 11, fig. 46, pl. 13, figs., 7–9, 11, 12, 14, pl. 14, figs. 6–7. Upper Triassic, Austria.
H. raridenticulata Müller, 1956a, p. 826, pl. 96, fig. 1. Lower Triassic, Nevada.
H. redunca Stanley, 1958, pp. 466–467, pl. 63, figs. 1–4. Upper Mississippian, Mississippi.
H. segaformis Bischoff, 1957, pp. 28–29, pl. 5, figs. 40, 41a, 41b, 43. Middle Mississippian, Germany.
H. triassica Müller, 1956a, p. 826, pl. 96, figs. 4, 5. Lower Triassic, Nevada.
H. unca Bischoff, 1956, pp. 124–125, pl. 10, figs. 37–41. Upper Devonian, Germany.
Holodontus Rhodes, 1953b, p. 303; *Holodontus superbus* Rhodes, 1953b. Upper Ordovician.
H. superbus Rhodes, 1953b, p. 304, pl. 21, figs. 125–127. Upper Ordovician, England.

Icriodella Rhodes, 1953b, pp. 285–286; *Icriodella superba* Rhodes, 1953b. Upper Ordovician.
I. deforma Rhodes, 1953b, p. 286, pl. 20, figs. 68–70. Upper Ordovician, England.
I elongata Rhodes, 1953b, p. 287, pl. 20, figs. 79–81. Upper Ordovician, England.
I. plana Rhodes, 1953b, p. 287, pl. 20, figs. 67, 74, 76. Upper Ordovician, England.
I. superba Rhodes, 1953b, p. 288, pl. 20, figs. 54, 58, 62, 63, 65, 78. Upper Ordovician, England.
I. superba var. *acuta* Rhodes, 1953b, p. 288, pl. 20, figs. 59, 60, 64, 66, 71–73, 77. Upper Ordovician, England.
Icriodidae Müller and Müller, 1957, p. 1105. A new family.
Icriodus angustus Stewart and Sweet, 1956, p. 267, pl. 33, figs. 4, 5, 11, 15. Middle Devonian, Ohio.
I. cornutus Sannemann, 1955b, p. 130, pl. 4, figs. 19a–19c, 20, 21. Upper Devonian, Germany.
I. darbyensis Klapper, 1958, p. 1086, pl. 141, figs. 9, 11, 12. Upper Devonian, Wyoming.
I. latericrescens beckmanni Ziegler, 1956, p. 102, pl. 6, figs. 1–5. Lower Devonian, Germany.
I. latericrescens bilatericrescens Ziegler, 1956, pp. 101–102, pl. 6, figs. 6–13. Lower Devonian, Germany.
I. mehli Klapper, 1958, pp. 1086–1087, pl. 141, figs. 2–3. Upper Devonian, Wyoming.
I. obliquimarginatus Bischoff and Ziegler, 1957, pp. 62–63, pl. 6, fig. 14. Middle Devonian, Germany.
I. pesavis Bischoff and Sannemann, 1958, pp. 96–97, pl. 12, figs. 1–4, 6, 7. Lower Devonian, Germany.

Keislognathus Rhodes, 1955, p. 130; *Keislognathus gracilis* Rhodes, 1955. Upper Ordovician.
K. gracilis Rhodes, 1955, p. 131, pl. 7, figs. 7, 8. Upper Ordovician, England.
Kladognathus Rexroad, 1958, p. 19; *Kladognathus prima* (Rexroad), 1957. Upper Mississippian.
K. mehli (Rexroad), 1957, p. 29, pl. 1, figs. 11–12. Upper Mississippian, Illinois.
K. prima (Rexroad), 1957, pp. 28–29, pl. 1, figs. 8–10. Upper Mississippian, Illinois.
Kockelella Walliser, 1957, pp. 34–35; *Kockelella variabilis* Walliser, 1957. Silurian.
K. variabilis Walliser, 1957, pp. 35–36, pl. 1, figs. 3–10. Silurian, Germany.

Lambdagnathus Rexroad, 1958, pp. 19–20; *Lambdagnathus fragilidens* Rexroad, 1958. Upper Mississippian.
L. fragilidens Rexroad, 1958, pp. 20–21, pl. 6, figs. 10–16. Upper Mississippian, Illinois, Indiana and Kentucky.
Ligonodina diversa Walliser, 1957, pp. 36–37, pl. 2, figs. 11–14. Silurian, Germany.
L. elongata Rhodes, 1953b, pp. 305–306, pl. 21, figs. 130, 131 Upper Ordovician, England.
L. extensa Rhodes, 1953b, p. 306, pl. 21, figs. 128, 129. Upper Ordovician, England.
L. fragilis Hass, 1953a, p. 82, pl. 15, fig. 1. Middle and Upper Mississippian, Texas.
L. franconica Sannemann, 1955b, p. 131, pl. 5, figs. 1–4. Upper Devonian, Germany.
L. hamata Rexroad, 1957, p. 32, pl. 1, figs. 24, 25. Upper Mississippian, Illinois.
L. ingens Walliser, 1957, pp. 37–38, pl. 2, fig. 20. Silurian. Germany.
L. monodentata Bischoff and Ziegler, 1956, pp. 148–149, pl. 14, fig. 13. Upper Devonian, Germany.
L. obunca Rexroad, 1957, pp. 32–33, pl. 1, figs. 22, 23. Upper Mississippian, Illinois.
L. roundyi Hass, 1953a, pp. 82–83, pl. 15, figs. 5–9. Middle and Upper Mississippian, Texas.
L. salopia Rhodes, 1953b, p. 307, pl. 23, figs. 245, 257, 260. Upper Silurian, England.
L. triassica Müller, 1956a, p. 827, pl. 96, fig. 17. Lower Triassic, Nevada.
L.? truncata Elias, 1956, p. 126, pl. 5, figs. 25–26. Upper Mississippian, Oklahoma.
L. valma Rhodes, 1953b, pp. 307–308, pl. 22, figs. 184, 185. Middle Ordovician, England.
Lonchodina aequiarcuata Müller, 1956a, pp. 827–828, pl. 96, fig. 9. Lower Triassic, Nevada.
L. epilonca Stanley, 1958, p. 469, pl. 67, fig. 2. Upper Mississippian, Mississippi.
L. furnishi Rexroad, 1958a, p. 22, pl. 4, figs. 11–13. Upper Mississippian, Illinois, Indiana and Kentucky.
L. greilingi Walliser, 1957, pp. 38–39, pl. 3, figs. 20–26. Silurian, Germany.
L. monodentata Bischoff and Ziegler, 1957, p. 68, pl. 20, fig. 17. Middle Devonian, Germany.
L. mulleri Tatge, 1956, p. 133, pl. 5, fig. 15. Middle Triassic, Germany.
L. nevadensis Müller, 1956a, p. 827, pl. 96, fig. 7. Lower Triassic, Nevada.
L. paraclarki Hass, 1953a, p. 83, pl. 16, figs. 15, 16. Middle and Upper Mississippian, Texas.
L. pirsoni Ziegler, 1958b, pp. 55–56, pl. 9, figs. 13–14. Upper Devonian, Germany.

L. paraclaviger Rexroad, 1958a, p. 22, pl. 4, figs. 7–10. Upper Mississippian, Illinois, Indiana and Kentucky.
L. ramulata Bischoff and Ziegler, 1957, pp. 69–70, pl. 10, figs. 1a, 1b, 2, 3. Middle Devonian, Germany.
L.? recurvata Bischoff, 1957, pp. 34–35, pl. 5, figs. 17, 18. Upper Mississippian, Germany.
L. regularis Elias, 1956, p. 122, pl. 5, figs. 19–21?. Upper Mississippian, Oklahoma.
L. richteri Bischoff and Ziegler, 1957, pp. 70–71, pl. 10, figs. 4a, 4b, 5a, 5b, 15a, 15b. Middle Devonian, Germany.
L. spengleri Huckriede, 1958, p. 152, pl. 10, figs. 54–56, pl. 11, fig. 6, pl. 12, fig. 9, pl. 13, figs. 1, 6, 10, pl. 14, fig. 11. Upper Triassic, Austria.
L. suevica Tatge, 1956, p. 134, pl. 5, fig. 16. Middle Triassic, Germany.
L. triassica Müller, 1956a, p. 828, pl. 96, fig. 10. Lower Triassic, Nevada.
L. valida Sannemann, 1955b, p. 132, pl. 6, figs. 10–11. Upper Devonian, Germany.
L. venusta Huckriede, 1958, pp. 152–153, pl. 11, fig. 25. Middle Triassic, Austria.

Mestognathus Bischoff, 1957, p. 36; *Mestognathus beckmanni* Bischoff, 1957. Upper Mississippian.
M. beckmanni Bischoff, 1957, p. 37, pl. 2, figs. 4a, 4b, 4c, 4d, 5, 6, 8, 9. Upper Mississippian, Germany.
Metalonchodina digitiformis Tatge, 1956, pp. 136–137, pl. 6, fig. 7. Middle Triassic, Germany.
M.? dinodoides Tatge, 1956, p. 135, pl. 6, fig. 4. Middle Triassic, Germany.
M. mediocris Tatge, 1956, p. 136, pl. 6, fig. 6. Middle Triassic, Germany.
M. triquetra Tatge, 1956, p. 137, pl. 6, fig. 5. Middle Triassic, Germany.
Microcoelodus panderi Branson, Mehl and Branson, 1951, p. 16, pl. 4, fig. 12. Upper Ordovician, Indiana.
Mixoconus Sweet, 1955b, pp. 244–245; *Mixoconus primus* Sweet, 1955b, Middle Ordovician.
M. primus Sweet, 1955b, p. 245, pl. 28, figs. 27, 28. Middle Ordovician, Colorado.

Neoprioniodus Rhodes and Müller, 1956, pp. 698–699; *Prioniodus conjuctus* Gunnell, 1931, p. 247, pl. 29, fig. 7. Ordovician to Lower Triassic.
N. alytus Stanley, 1958, p. 471, pl. 66, fig. 1. Upper Mississippian, Mississippi.
N. biscuspidatus Müller, 1956a, pp. 828–829, pl. 95, figs. 14–17. Lower Triassic, Nevada.
N. bransoni Müller, 1956a, p. 829, pl. 95, figs. 19–21. Lower Triassic, Nevada.
N. camurus Rexroad, 1957, pp. 33–34, pl. 2, figs. 18–20. Upper Mississippian, Illinois.
N. epemoebus Rexroad, 1957, p. 34, pl. 2, figs. 15, 21. Upper Mississippian, Illinois.
N. erectus Rexroad, 1957, p. 34, pl. 2, figs. 23, 25. Upper Mississippian, Illinois.
N. loxus Rexroad, 1957, pp. 34–35, pl. 2, figs. 8, 9, 14. Upper Mississippian, Illinois.
N. striatus Rexroad, 1957, p. 35, pl. 2, figs. 11, 12. Upper Mississippian, Illinois.
N. tenuis Rexroad, 1957, p. 35, pl. 2, figs. 13, 16. Upper Mississippian, Illinois.
N. unicornis Müller, 1956a, p. 829, pl. 95, fig. 18. Lower Triassic, Nevada.
Nericodus Lindström, 1954, p. 570; *Nericodus capillamentum* Lindström, 1954. Lower Ordovician.
N. capillamentum Lindström, 1954, p. 570, pl. 6, figs. 41–42. Lower Ordovician, Sweden.
Nothognathella sublaevis Sannemann, 1955b, pp. 132–133, pl. 3, figs. 10a, 10b, 12a, 12b. Upper Devonian, Germany.

Oepikodus Lindström, 1954, p. 570; *Oepikodus smithensis* Lindström, 1954. Lower Ordovician.
O. crassulus Lindström, 1954, pp. 570–571, pl. 5, figs. 36–37. Lower Ordovician, Sweden.
O. smithensis Lindström, 1954, pp. 571–572, pl. 6, figs. 1–3. Lower Ordovician, Sweden.
Oistodus contractus Lindström, 1954, p. 573, pl. 4, figs. 45–46, text-fig. 3H. Lower Ordovician, Sweden.
O. delta Lindström, 1954, pp. 573–574, pl. 3, figs. 3–9. Lower Ordovician, Sweden.
O. elongatus Lindström, 1954, p. 574, pl. 4, figs. 32–33, text-fig. 5b. Lower Ordovician, Sweden.
O. forceps Lindström, 1954, pp. 574–576, pl. 4, figs. 9–13, text-fig. 3M. Lower Ordovician, Sweden.
O. gracilis Lindström, 1954, p. 576, pl. 5, figs. 1–2. Lower Ordovician, Sweden.
O. linguatus Lindström, 1954, pp. 577–578, pl. 3, figs. 39–41. Lower Ordovician, Sweden.
O. linguatus var. *complanatus* Lindström, 1954, p. 578, pl. 3, figs. 37–38. Lower Ordovician, Sweden.
O. linguatus var. *extenuatus* Lindström, 1954, pp. 578–579, pl. 3, fig. 42. Lower Ordovician, Sweden.
O. longiramis Lindström, 1954, p. 579, pl. 4, figs. 35–37. Lower Ordovician, Sweden.
O. selene Lindström, 1954, p. 580, pl. 4, figs. 19–20. Lower Ordovician, Sweden.
O. triangularis Lindström, 1954, p. 581, pl. 4, figs. 14–18. Lower Ordovician, Sweden.
Oneotodus Lindström, 1954, p. 581; *Distacodus? simplex* Furnish, 1938, p. 328, pl. 42, figs. 24–25, text-fig. 1–0. Lower Ordovician – Lower Devonian.
O.? beckmanni Bischoff and Sannemann, 1958, pp. 98–99, pl. 15, figs. 22–25. Lower Devonian, Germany.
O. variabilis Lindström, 1954, p. 582, pl. 2, figs. 14–18, 47, pl. 5, figs. 4, 5, text-fig. 6. Lower Ordovician, Sweden.
Ozarkodina ballai Bischoff and Ziegler, 1957, pp. 74–75, pl. 13, figs. 1a–1c, 2. Middle Devonian, Germany.
O. ? bella Rexroad, 1957, p. 37, pl. 2, figs. 3, 4. Upper Mississippian, Illinois.
O. breviramulis Tatge, 1956, p. 139, pl. 5, fig. 12. Middle Triassic, Germany.
O. compressa Rexroad, 1957, p. 36, pl. 2, figs. 1, 2. Upper Mississippian, Illinois.
O. curvata Rexroad, 1958, p. 24, pl. 4, figs. 1–3. Upper Mississippian, Illinois, Indiana and Kentucky.
O. deflecta Stanley, 1958, pp. 472–473, pl. 65, figs. 4–5. Upper Mississippian, Mississippi.
O. denckmanni Ziegler, 1956, p. 103, pl. 6, figs. 30–31, pl. 7, figs. 1–2. Lower Devonian, Germany.
O. inclinata Glenister, 1957, p. 735, pl. 88, figs. 3, 7. Upper Ordovician, Iowa.
O. kockeli Tatge, 1956, pp. 137–138, pl. 5, figs. 13–14. Middle Triassic, Germany.
O. kutscheri Bischoff and Ziegler, 1957, p. 79, pl. 12, figs. 12, 14. Middle Devonian, Germany.
O. lata Bischoff and Ziegler, 1957, pp. 76–77, pl. 20, figs. 9–16. Middle Devonian, Germany.
O. media Walliser, 1951, pp. 40–41, pl. 1, figs. 21–25. Silurian, Germany.
O. pachyamba Stanley, 1958, pp. 473–474, pl. 68, figs. 1–2. Upper Mississippian, Mississippi.

O. recta Rexroad, 1957, pp. 36–37, pl. 2, figs. 5–6. Upper Mississippian, Illinois.
O. rhenana Bischoff and Ziegler, 1956, p. 153, pl. 14, fig. 19. Upper Devonian, Germany.
O. saginata Huckriede, 1958, pp. 153–154, pl. 13, figs. 16, 17, 20. Middle Triassic, Austria.
O. tortilis Tatge, 1956, p. 138, pl. 5, figs. 9–11. Middle Triassic, Germany.
O. toxata Bischoff and Ziegler, 1957, p. 80, pl. 12, figs. 16–17. Middle Devonian, Germany.
O. willsi Rhodes and Dineley, 1957, p. 364, pl. 38, figs. 1, 5. Middle(?) Devonian, England.
O. ziegleri Walliser, 1957, p. 41, pl. 1, figs. 26–30. Silurian, Germany.

Palmatodella orthogonica Ziegler, 1958b, p. 56, pl. 12, figs. 11–12. Upper Devonian, Germany.
P. unca Sannemann, 1955b, p. 134, pl. 4, figs. 10–11. Upper Devonian, Germany.
Palmatolepis crepida Sannemann, 1955b, p. 134, pl. 6, fig. 21, text-fig. 1. Upper Devonian, Germany.
P. proversa Ziegler, 1958b, pp. 62–63, pl. 3, figs. 11–12; pl. 4, figs. 1–14. Upper Devonian, Germany.
P. quadrantinodosalobata Sannemann, 1955a, p. 328, pl. 24, fig. 6. Upper Devonian, Germany.
P. rhenana Bischoff, 1956, pp. 129–130, pl. 8, figs. 26–28, 30, pl. 10, fig. 7. Upper Devonian, Germany.
P. rhomboidea Sannemann, 1955a, p. 329, pl. 24, fig. 14. Upper Devonian, Germany.
P. subgracilis Bischoff, 1956, pp. 130–131, pl. 9, figs. 12, 19, pl. 10, fig. 13. Upper Devonian, Germany.
P. tenuipunctata Sannemann, 1955b, p. 136, pl. 6, fig. 22, text-fig. 2. Upper Devonian, Germany.
P. termini Sannemann, 1955b, p. 149, pl. 1, figs. 1–3. Upper Devonian, Germany.
P. triangularis Sannemann, 1955a, pp. 327–328, pl. 24, fig. 3. Upper Devonian, Germany.
P. ultima Ziegler, 1958b, p. 67, pl. 9, figs. 2, 6, 10. Upper Devonian, Germany.
P. (Deflectolepis) Müller 1956c, pp. 16–17; *Palmatolepis (Deflectolepis) deflectens* Müller, 1956c. Upper Devonian.
P. (D.) coronata Müller, 1956c, p. 31, pl. 10, figs. 17–18. Upper Devonian, Germany.
P. (D.) deflectens Müller, 1956c, p. 32, pl. 11, figs. 28–39. Upper Devonian, Germany.
P. (Manticolepis) Müller, 1956c, p. 16; *Palmatolepis subrecta* Miller and Youngquist, 1947, pp. 513–514, pl. 75, figs. 7–11. Upper Devonian.
P. (M.) amana Müller and Müller, 1957, p. 1101, pl. 140, fig. 5. Upper Devonian, Iowa.
P. (M.) charlottae Müller, 1956c, pp. 20–21, pl. 2, figs. 14–16. Upper Devonian, Germany.
P. (M.) cruciformis Müller, 1956c, p. 19, pl. 2, fig. 9. Upper Devonian, Germany.
P. (M.) hassi Müller and Müller, 1957, pp. 1102–1103, pl. 139, fig. 2, pl. 140, figs. 2, 4. Upper Devonian, Iowa.
P. (M.) martenbergensis Müller, 1956c, pp. 19–20, pl. 1, figs. 3–8, pl. 2, figs. 10–13. Upper Devonian, Germany.
P. (M.) nasuta Müller, 1956c, pp. 23–24, pl. 6, figs. 31–35. Upper Devonian, Germany.
P. (M.) prominens Müller, 1956c, pp. 22–23, pl. 5, figs. 25, 26, 28–30. Upper Devonian, Germany.
P. (M.) transitans Müller, 1956c, pp. 18–19, pl. 1, figs. 1–2. Upper Devonian, Germany.
P. (M.) wildungensis Müller, 1956c, p. 22, pl. 4, fig. 20?, pl. 5, figs. 21–24. Upper Devonian, Germany.
P. (Palmatolepis) ampla Müller, 1956c, pp. 28–29, pl. 9, figs. 35, 36. Upper Devonian, Germany.
P. (P.) gonioclymeniae Müller, 1956c, pp. 26–27, pl. 7, figs. 12, 16–19. Upper Devonian, Germany.
P. (P.) inflexa Müller, 1956c, pp. 30–31, pl. 10, figs. 3–11. Upper Devonian, Germany.
P. (P.) linguiformis Müller, 1956c, pp. 24–25, pl. 7, figs. 1–7. Upper Devonian, Germany.
P. (P.) maxima Müller, 1956c, p. 29, pl. 9, figs. 37–40, pl. 10, figs. 1–2. Upper Devonian, Germany.
P. (P.) schindewolfi Müller, 1956c, pp. 27–28, pl. 8, figs. 22–31, pl. 9, fig. 33, pl. 11, fig. 27?. Upper Devonian, Germany.
Paltodus angularis Branson, Mehl and Branson, 1951, p. 8, pl. 1, figs. 34–39. Upper Ordovician, Indiana and Kentucky.
P. equicostatus Rhodes, 1953b, p. 297, pl. 21, figs. 106–109, pl. 22, figs. 162, 165. Middle to Upper Ordovician, England.
P. feulneri Glenister, 1957, p. 728, pl. 85, fig. 11. Upper Ordovician, Iowa.
P. inconstans Lindström, 1954, pp. 583–584, pl. 4, figs. 3–8. Lower Ordovician, Sweden.
P. intermedius Branson, Mehl and Branson, 1951, p. 7, pl. 1, figs. 9–15. Upper Ordovician, Indiana and Kentucky.
P. recurvatus Rhodes, 1953b, p. 297, pl. 23, figs. 219–220. Upper Silurian, England.
P. robustus Branson, Mehl and Branson, 1951, p. 8, pl. 1, figs. 28–33. Upper Ordovician, Indiana and Kentucky.
P. staufferi Branson, Mehl and Branson, 1951, pp. 7–8, pl. 1, figs. 23–27. Upper Ordovician, Indiana and Kentucky.
Paracordylodus Lindström, 1954, p. 584; *Paracordylodus gracilis* Lindström, 1954. Lower Ordovician.
P. gracilis Lindström, 1954, pp. 584–585, pl. 6, figs. 11–12. Lower Ordovician, Sweden.
Pelekysgnathus planus Sannemann, 1955b, p. 149, pl. 4, figs. 22–23. Upper Devonian, Germany.
P. ? primitiva Bischoff and Ziegler, 1957, p. 83, pl. 21, figs. 5–9. Middle Devonian, Germany.
Periodon Hadding, 1913, p. 33, *Periodon aculeatus* Hadding, 1913. Middle Ordovician. Defined by Lindström in 1955, pp. 109–110.
P. aculeatus Hadding, 1913, p. 33, pl. 1, fig. 14. Middle Ordovician, Sweden. (Redefined by Lindström, 1955, p. 110, pl. 22, figs. 10, 11, 14–16, 35.)
Plectospathodus contrarius Rhodes, 1953b, p. 322, pl. 23, figs. 225, 247, 249, 250. Upper Silurian, England.
P. elegans Rhodes, 1953b, p. 323, pl. 23, figs. 255, 263, 264. Upper Silurian, England.
P. extensus Rhodes, 1953b, p. 323, pl. 23, figs. 236–240. Upper Silurian, England.
P. robustus Bischoff and Sannemann, 1958, pp. 101–102, pl. 14, figs. 11–14. Lower Devonian, Germany.
Polycaulodus reversus Sweet, 1955b, p. 251, pl. 28, fig. 26. Middle Ordovician, Colorado.
POLYGNATHACEAE Müller and Müller, 1957, p. 1083. New superfamily which includes the following families: Polygnathidae Ulrich and Bassler, 1925; Gnathodontidae Branson and Mehl, 1944; and Icriodidae Müller and Müller, 1957.
Polygnathus abneptis Huckriede, 1958, pp. 156–157, pl. 11, fig. 33, pl. 12, figs. 30–36, pl. 14, figs. 1, 2, 3, 5, 12–14, 16–22, 26, 27, 32, 47–58. Upper Triassic, Austria.
P. amana Müller and Müller, 1957, pp. 1085–1086, pl. 135, fig. 4. Upper Devonian, Iowa.
P. ancyrognathoidea Ziegler, 1958b, pp. 69–70, pl. 9, figs. 8, 11, 16–20?, 21, text-fig. 7. Upper Devonian, Germany.
P. angustipennata Bischoff and Ziegler, 1957, p. 85, pl. 2, figs. 16a, 16b, pl. 3, figs. 1–3. Middle Devonian, Germany.
P. beckmanni Bischoff and Ziegler, 1957, p. 86, pl. 15, fig. 25. Middle Devonian, Germany.

P. dengleri Bischoff and Ziegler, 1957, pp. 87–88, pl. 15, figs. 14, 15, 17–24, pl. 16, figs. 1–4. Middle Devonian, Germany.

P. dubia asymmetrica Bischoff and Ziegler, 1957, pp. 88–89, pl. 16, figs. 20–22, pl. 21, fig. 3. Middle Devonian, Germany.

P. eiflia Bischoff and Ziegler, 1957, pp. 89–90, pl. 4, figs. 5–7. Middle Devonian, Germany.

P. independensis Müller and Müller, 1957, pp. 1088–1089, pl. 141, figs. 2, 9. Upper Devonian, Iowa.

P. kockeliana Bischoff and Ziegler, 1957, p. 91, pl. 2, figs.1–12. Middle Devonian, Germany.

P. mungoensis Diebel, 1956b, pp. 431–432, pl. 1, figs. 1–20, pl. 2, figs. 1–4, pl. 3, fig. 1, pl. 4, fig. 1. Upper Cretaceous, Cameroons.

P. procerus Sannemann, 1955b, p. 150, pl. 1, figs. 11a, 11b. Upper Devonian, Germany.

P. robusticostata Bischoff and Ziegler, 1957, pp. 95–96, pl. 3, figs. 4–10. Middle Devonian, Germany.

P. stainbrooki Downs and Youngquist, 1950, p. 671, pl. 87, figs. 19–20. Middle Devonian, Iowa.

P. styriaea Flugel and Ziegler, 1957, p. 47, pl. 1, figs. 11–13. Upper Devonian, Germany.

P. tethydis Huckriede, 1958, pp. 157–158, pl. 11, figs. 39, 40, pl. 12, figs. 1, 38, pl. 13, figs. 2–5. Upper Triassic, Austria.

P. trigonica Bischoff and Ziegler, 1957, pp. 97–98, pl. 5, figs. 1–6. Middle Devonian, Germany.

P. unicornis Müller and Müller, 1957, pp. 1089–1090, pl. 135, figs. 5–7, pl. 141, fig. 10. Upper Devonian, Iowa.

P.? variabilis Bischoff and Ziegler, 1957, pp. 99–100, pl. 18, figs. 8–17, pl. 19, figs. 10, 11, 17. Middle Devonian, Germany.

P. wyomingensis Klapper, 1958, pp. 1090–1091, pl. 142, figs. 5–8. Upper Devonian, Wyoming.

Pravognathus aengensis Lindström, 1954, p. 585, pl. 5, figs. 10–13. Lower Ordovician, Sweden.

Prioniodella? biden Elias, 1956, p. 113, pl. 2, fig. 38. Upper Mississippian, Oklahoma.

P. ctenoides Tatge, 1956, pp. 139–140, pl. 5, fig. 7. Middle Triassic, Germany.

P. decrescens Tatge, 1956, p. 140, pl. 5, fig. 8. Middle Triassic, Germany.

P. galea Elias, 1956, p. 113, pl. 2, figs. 52–54. Upper Mississippian, Oklahoma.

P. galea var. *uniden* Elias, 1956, p. 113, pl. 2, fig. 55. Upper Mississippian, Oklahoma.

P. inclinata Rhodes, 1953b, p. 324, pl. 23, figs. 233–235. Upper Silurian, England.

P. pectiniformis Huckriede, 1958, pp. 158–159, pl. 13, figs. 18, 19. Upper Triassic, Austria.

Prioniodina arlingtonensis Stewart and Sweet, 1956, p. 271, pl. 34, fig. 10. Middle Devonian, Ohio.

P. bischoffi Flugel and Ziegler, 1957, p. 48, pl. 4, fig. 5. Upper Mississippian, Germany.

P.? deflexa Lindström, 1954, p. 586, pl. 6, figs. 31–35. Lower Ordovician, Sweden.

P. densa Lindström, 1954, pp. 586–587, pl. 6, fig. 20. Lower Ordovician, Sweden.

P. diprion Lindström, 1954, p. 587, pl. 5, fig. 43. Lower Ordovician, Sweden.

P. flabellum Lindström, 1954, pp. 587–588, pl. 6, figs. 23–25. Lower Ordovician, Sweden.

P. inflata Lindström, 1954, p. 588, pl. 6, figs. 26–27. Lower Ordovician, Sweden.

P. insignis Tatge, 1956, p. 141, pl. 5, fig. 20. Middle Triassic, Germany.

P. kochi Huckriede, 1958, p. 159; pl. 11, fig. 37; pl. 12, figs. 11, 12; pl. 14, fig. 4. Upper Triassic, Austria.

P. lata Bischoff, 1957, p. 47, pl. 5, fig. 38–39. Upper Mississippian, Germany.

P. latidentata Tatge, 1956, pp. 140–141, pl. 5, fig. 23. Middle Triassic, Germany.

P. oregonia Branson, Mehl and Branson, 1951, pp. 15–16, pl. 3, fig. 18, pl. 4, figs. 28–32. Upper Ordovician, Kentucky.

P. schneideri Bischoff and Ziegler, 1957, pp. 107–108, pl. 8, figs. 10–11a, 11b. Middle Devonian, Germany.

Prioniodus acodiformis Lindström, 1954, p. 591, pl. 5, fig. 42. Lower Ordovician, Sweden.

P. brevifundus Elias, 1956, p. 113, pl. 4, figs. 24–25. Upper Mississippian, Oklahoma.

P. evae Lindström, 1954, pp. 589–590, pl. 6, figs. 4–10. Lower Ordovician, Sweden.

P. federatus Elias, 1956, p. 110, pl. 2, figs. 30–32,48–50?. Upper Mississippian, Oklahoma.

P. gracilis Rhodes, 1955, p. 136, pl. 8, figs. 5, 6. Upper Ordovician, England.

P. inclinatus Hass, 1953a, p. 87, pl. 16, figs. 10–14. Middle and Upper Mississippian, Texas.

P. ligo Hass, 1953a, pp. 87–88, pl. 16, figs. 1–3. Middle and Upper Mississippian, Texas.

P. navis Lindström, 1954; pp. 590–591, pl. 5, figs. 31–35. Lower Ordovician, Sweden.

P. roundyi Hass, 1953a, p. 88, pl. 15, figs. 2, 3. Middle and Upper Mississippian, Texas.

P. roundyi var. *dividen* Elias, 1956, p. 110, pl. 2, figs. 39–41. Upper Mississippian, Oklahoma.

P. roundyi var. *parviden* Elias, pp. 109, 112, pl. 2, figs. 26–27. Upper Mississippian, Oklahoma.

P. singularis Hass, 1953a, p. 88, pl. 16, fig. 4. Middle and Upper Mississippian, Texas.

P. solidiformis Elias, 1956, pp. 109–110, pl. 2, figs. 28–29. Upper Mississippian, Oklahoma.

P. triangularis Lindström, 1954, pp. 591–592, pl. 5, figs. 45–46. Lower Ordovician, Sweden.

Pseudopolygnathus? kayseri Bischoff and Ziegler, 1956, p. 162, pl. 11, figs. 3–6. Upper Devonian(?) to Lower Mississippian, Germany.

P. marburgensis Bischoff and Ziegler, 1956, pp. 162–163, pl. 11, figs. 9, 11–13. Upper Devonian, Germany.

P. micropunctata Bischoff and Ziegler, 1956, pp. 163–164, pl. 11, figs. 7, 8, 10. Upper Devonian, Germany.

Ptilognathus Elias, 1956, p. 114; *Ptilognathus fayi* Elias, 1956. Upper Mississippian, Oklahoma.

P. fayi Elias, 1956, p. 114, pl. 2, fig. 33. Upper Mississippian, Oklahoma.

Pygodus Lamont and Lindström, 1957, pp. 67–68; *Pygodus anserinus* Lamont and Lindström, 1957. Lower Ordovician.

P. anserinus Lamont and Lindström, 1957, pp. 67–69, text-fig. 1, pl. 5, figs. 12–13. Lower Ordovician, Sweden and Scotland.

Rhipidognathus Branson, Mehl and Branson, 1951, p. 10; *Rhipidognathus symmetrica* Branson, Mehl and Branson, 1951. Upper Ordovician.

R. curvata Branson, Mehl and Branson, 1951, pp. 10–11, pl. 3, figs. 1–7. Upper Ordovician, Kentucky and Indiana.

R. paucidentata Branson, Mehl and Branson, 1951, p. 10, pl. 2, figs. 18–28, pl. 3, fig. 30. Upper Ordovician, Indiana and Kentucky.

R. spuria Branson, Mehl and Branson, 1951, p. 11, pl. 2, fig. 17, pl. 3, figs. 8, 9. Upper Ordovician, Indiana.

R. symmetrica Branson, Mehl and Branson, 1951, p. 10, pl. 2, figs. 29–37, pl. 3, fig. 31. Upper Ordovician, Indiana and Kentucky.

Roundya Hass, 1953*a*, pp. 88–89; *Roundya barnettana* Hass, 1953*a*. Upper Ordovician to Middle Triassic, Upper Cretaceous (?).

R. aurita Sannemann, 1955b, p. 153, pl. 2, figs. 3a, 3b, pl. 5, fig. 11. Upper Devonian, Germany.

R. barnettana Hass. 1953a, p. 89, pl. 16, figs. 8, 9. Middle and Upper Mississippian, Texas.

R. bidentata Tatge, 1956, pp. 142–143, pl. 6, fig. 10. Middle Triassic, Germany.

R. brevipennata Sannemann, 1955b, p. 153, pl. 2, fig. 1. Upper Devonian, Germany.

R. costata Rexroad, 1958, p. 26, pl. 2, figs. 5–8. Upper Mississippian, Illinois, Indiana and Kentucky.

R. diminuta Rhodes, 1955, p. 137, pl. 8, figs. 9, 12, pl. 9, fig. 6. Upper Ordovician, England.

R. franca Sannemann, 1955b, p. 153, pl. 5, figs. 5–7. Upper Devonian, Germany.

R. latipennata Ziegler, 1958b, p. 70, pl. 12, fig. 9. Upper Devonian, Germany.

R. lautissima Huckriede, 1958, p. 160, pl. 11, fig. 41, pl. 13, figs. 13, 15. Upper Triassic, Austria.

R. magnidentata Tatge, 1956, pp. 143–144, pl. 6, figs. 12–13. Middle Triassic, Germany.

R. messneri Tatge, 1956, p. 143, pl. 6, fig. 11. Middle Triassic, Germany.

R. triangularis Bischoff and Ziegler, 1957, pp. 111–112, pl. 12, figs. 1–2, 6a–6b. Middle Devonian, Germany.

R. wildungenensis Bischoff and Ziegler, 1957, pp. 112–113, pl. 11, figs. 9–12. Middle Devonian, Germany.

Sagittodontus Rhodes, 1953b, p. 310; *Sagittodontus robustus* Rhodes, 1953. Upper Ordovician.

S. gracilis Sannemann, 1955*c*, p. 29, pl. 2, fig. 2, pl. 3, fig. 6. Ordovician, Germany.

S. robustus Rhodes, 1953b, p. 311, pl. 21, figs. 141, 142. Upper Ordovician, England.

S. robustus var. *distaflexus* Rhodes, 1953*b*, p. 312, pl. 21, figs. 137, 138. Upper Ordovician, England.

S. robustus var. *erectus* Rhodes, 1953*b*, p. 311, pl. 21, figs. 143, 151, 152. Upper Ordovician, England.

Scandodus Lindström, 1954, p. 592; *Scandodus furnishi* Lindström, 1954, Lower Ordovician.

S. furnishi Lindström, 1954, p. 592, pl. 5, fig. 3. Lower Ordovician, Sweden.

S. pipa Lindström, 1954, p. 593, pl. 4, figs. 38–42, text-fig. 3P. Lower Ordovician, Sweden.

S. rectus Lindström, 1954, pp. 593–594, pl. 4, figs. 21–25, text-fig. 3K. Lower Ordovician, Sweden.

Scolopodus brevis Sweet, 1955b, p. 252, pl. 28, figs. 13, 23. Middle Ordovician, Colorado.

S. devonicus Bischoff and Sannemann, 1958, p. 103, pl. 15, fig. 19. Lower Devonian, Germany.

S. peselephantis Lindström, 1954, p. 595, pl. 2, figs. 19–20, text-fig. 3Q. Lower Ordovician, Sweden.

S. rex Lindström, 1954, pp. 595–596, pl. 3, fig. 32. Lower Ordovician, Sweden.

S. rex var. *paltodiformis* Lindström, 1954, p. 596, pl. 3, figs. 33–34. Lower Ordovician, Sweden.

Scutula Sannemann, 1955b, p. 154; *Scutula venusta* Sannemann, 1955b. Upper Devonian.

S. bipennata Sannemann, 1955b, p. 154, pl. 4, figs. 5, 8a, 8b, 9. Upper Devonian, Germany.

S. sinepennata Ziegler, 1958b, p. 71, pl. 12, figs. 25, 29. Upper Devonian, Germany.

S. venusta Sannemann, 1955b, p. 155, pl. 4, figs. 6a, 6b, 7. Upper Devonian, Germany.

Solenodella equiden Elias 1956, p. 114, pl. 2, figs. 36–37. Upper Mississippian, Oklahoma.

S. fissiden Elias, 1956, p. 114, pl. 2, figs. 34–35. Upper Mississippian, Oklahoma.

S. multiden Elias, 1956, p. 114, pl. 2, fig. 58. Upper Mississippian, Oklahoma.

S. uniden Elias, 1956, p. 114, pl. 2, figs. 56–57, Upper Mississippian, Oklahoma.

Spathognathodus asymmetricus Bischoff and Sannemann, 1958, pp. 104–105, pl. 12, fig. 19, pl. 13, fig. 1. Lower Devonian, Germany.

S. bidens Youngquist and Miller, 1949, p. 621, pl. 101, fig. 5. Upper Mississippian, Iowa.

S. bidentatus Bischoff and Ziegler, 1957, pp. 114–115, pl. 6, figs. 8–13. Middle Devonian, Germany.

S. bipennatus Bischoff and Ziegler, 1957, pp. 115–116, pl. 21, figs. 31a–31c. Middle Devonian, Germany.

S. brevis Bischoff and Ziegler, 1957, pp. 116–117, pl. 19, figs. 24, 27–29. Middle Devonian, Germany.

S. campbelli Rexroad, 1957, pp. 37–38, pl. 3, figs. 13–15. Upper Mississippian, Illinois.

S. cristagalli Huckriede, 1958, pp. 161–162, pl. 10, figs. 10–15, 18. Lower Triassic, West Pakistan.

S. cristula Youngquist and Miller, 1949, p. 621, pl. 101, figs. 1–3. Upper Mississippian, Iowa.

S. frankenwaldensis Bischoff and Sannemann, pp. 105–106, pl. 13, figs. 6, 10, 11, 13. Lower Devonian, Germany.

S. fundamentatus Walliser, 1957, p. 47, pl. 1, figs. 11–15. Silurian, Germany.

S. isarcica Huckriede, 1958, p. 162, pl. 10, figs. 6, 7. Lower Triassic, Austria.

S. miniden Elias, 1956, p. 120, pl. 3, figs. 43–45. Upper Mississippian, Oklahoma.

S. pellaensis Youngquist and Miller, 1949, p. 622, pl. 101, fig. 5. Upper Mississippian, Iowa.

S. planus Bischoff and Ziegler, 1957, p. 117, pl. 19, figs. 34, 35. Middle Devonian, Germany.

S. sannemanni Bischoff and Ziegler, 1957, pp. 117–118, pl. 19, figs. 15, 19–23, 25. Middle Devonian, Germany.

S. sannemanni treptus Ziegler, 1958b, pp. 72–73, pl. 12, figs. 1–3. Upper Devonian, Germany.

S. spiculus Youngquist and Miller, 1949, p. 622, pl. 101, fig. 4, Upper Mississippian, Iowa.

S. spinulicostatus ultimus Bischoff, 1957, pp. 57–58, pl. 4, figs. 24a–24c, 25, 26. Upper Devonian, Germany.

S. steinhornensis Ziegler, 1956, pp. 104–105, pl. 7, figs. 3–10. Lower Devonian, Germany.

S. transitans Bischoff and Sannemann, 1958, pp. 107–108, pl. 13, figs. 4, 5, 12, 14. Lower Devonian, Germany.

S. wurmi Bischoff and Sannemann, 1958, pp. 108–109, pl. 14, figs. 4–10. Lower Devonian, Germany.

Stereoconus maximus Rhodes, 1953b, p. 289, pl. 21, figs. 134–135. Upper Ordovician, England.

Strachanognathus Rhodes, 1955, pp. 131–132; *Strachanognathus parvus* Rhodes, 1955, Upper Ordovician.

S. parvus Rhodes, 1955, pp. 132–133, pl. 8, figs. 1–4. Upper Ordovician, England.

Streptognathus primus Elias, 1956, p. 120, pl. 3, figs. 59–61. Upper Mississippian, Oklahoma.

S. sulcoplicatus Youngquist, Hawley and Miller, 1951, p. 363, pl. 54, figs. 7–9, 16, 17, 22–24. Middle Permian, Idaho.

Subbryantodus roundyi Hass, 1953a, p. 89, pl. 14, figs. 3–6. Middle and Upper Mississippian, Texas.

S. stipans Rexroad, 1957, p. 39, pl. 4, fig. 1. Upper Mississippian, Illinois.

Tetraprioniodus Lindström, 1954, p. 596; *Tetraprioniodus robustus* Lindström, 1954. Lower Ordovician. (*Rosagnathus* is a junior synonym of this unit, see Rhodes, 1955, p. 138.)

T. denticulatus Lindström, 1954, pp. 596–597, pl. 5, fig. 44. Lower Ordovician, Sweden.

T. robustus Lindström, 1954, p. 597, pl. 6, figs. 13–15. Lower Ordovician, Sweden.

T. superbus (Rhodes), 1955, pp. 129–130, pl. 7, figs. 1–4. Upper Ordovician, England.

Trapezognathus Lindström, 1954, p. 597; *Trapezognathus quadrangulum* Lindström, 1954. Lower Ordovician, Sweden.

T. quadrangulum Lindström, 1954, p. 598, pl. 5, figs. 38–41. Lower Ordovician, Sweden.

Trichonodella aboroflexa Rhodes, 1953b, pp. 312–313, pl. 23, figs. 231, 241, 242. Upper Silurian, England.

T. alae Lindström, 1954, p. 599, pl. 6, figs. 38–40. Lower Ordovician, Sweden.

T. divaricata Rhodes, 1953b, p. 313, pl. 21, figs. 124, 140, 145, 146. Upper Ordovician, England.

T. flabellum Lindström, 1954, pp. 599–600, pl. 6, figs. 28–30. Lower Ordovician, Sweden.

T. flexa Rhodes, 1953b, pp. 313–314, pl. 22, figs. 181–183, 188, 189, 191, 192. Middle Ordovician, England.

T. fragilis Rexroad, 1957, p. 40, pl. 4, figs. 6, 7. Upper Mississippian, Illinois.

T. gracilis Rhodes, 1953b, pp. 314–315, pl. 21, figs. 144, 147–150. Upper Ordovician, England.

T. imperfecta Rexroad, 1957, p. 41, pl. 4, figs. 4, 5. Upper Mississippian, Illinois.

T. inclinata Rhodes, 1953b, p. 315, pl. 22, figs. 176, 177, 186. Middle Ordovician, England.

T. inconstans Walliser, 1957, pp. 50–51, pl. 3, figs. 10–17. Silurian, Germany.

T. irregularis Lindström, 1954, p. 600, pl. 6, figs. 21–22. Lower Ordovician, Sweden.

T. longa Lindström, 1954, pp. 600–601, pl. 6, figs. 47–48. Lower Ordovician, Sweden.

T. longa var. *minor* Lindström, 1954, p. 601, pl. 6, figs. 16–19. Lower Ordovician, Sweden.

T. nitida Branson, Mehl and Branson, 1951, p. 14, pl. 4, figs. 15, 16. Upper Ordovician, Kentucky and Indiana.

T. undulata Branson, Mehl and Branson, 1951, p. 14, pl. 3, figs. 24–26, pl. 4, figs. 10, 11, 14, 22. Upper Ordovician, Indiana and Kentucky.

Tripodellus Sannemann, 1955b, p. 155; *Tripodellus flexuosus* Sannemann, 1955b. Upper Devonian.

T. flexuosus Sannemann, 1955b, p. 155, pl. 4, figs. 16a, 16b. Upper Devonian, Germany.

T. robustus Bischoff, 1957, pp. 58–59, pl. 6, figs. 40. Upper Devonian, Germany.

Zygognathus Branson, Mehl and Branson, 1951, pp. 11–12; *Zygognathus pyramidalis* Branson, Mehl and Branson, 1951. Upper Ordovician.

Z.? abnormis Branson, Mehl and Branson, 1951, p. 14, pl. 3, fig. 20. Upper Ordovician, Kentucky.

Z. plebia Branson, Mehl and Branson, 1951, pp. 12–13. pl. 3, figs. 22, 23, pl. 4, figs. 1–9. Upper Ordovician, Indiana and Kentucky.

Z. pyramidalis Branson, Mehl and Branson, 1951, p. 12, pl. 3, figs. 10–16, 21. Upper Ordovician, Indiana and Kentucky.

ASSEMBLAGES

Duboisella Rhodes, 1952, p. 895; *Duboisella typica* Rhodes, 1952. Upper Devonian(?), Upper Mississippian to Lower Permian. "Natural conodont assemblages consisting of paired conodonts of the 'form genera' *Ligonodina*, *Lonchodina*, *Hibbardella*, *Metalonchodina*, and *Prioniodus*."

D. typica Rhodes, 1952, pp. 895–898, pl. 128, figs. 1–6. Upper Pennsylvanian, Illinois. "Natural conodont assemblages made up of two pairs of *Ligonodina*, two pairs of *Lonchodina*, one pair *Hibbardella*, one pair of *Metalonchodina*, and one pair of *Prioniodus*."

Illinella Rhodes, 1952, pp. 898–899; *Illinella typica* Rhodes, 1952. Middle Pennsylvanian to Lower Permian. "Natural conodont assemblages consisting of paired conodonts of the 'form genera' *Gondolella*, *Lonchodus (Centrodus)* and *Lonchodina*."

I. typica Rhodes, 1952, pp. 899–901, pl. 129, figs. 8–13. Middle Pennsylvanian, Illinois.

Scottognathus Rhodes, 1953a, p. 612; *Scottognathus typicus* (Rhodes) 1952. Pennsylvanian to Lower Permian. "Natural conodont assemblage consisting of paired conodonts of the 'form genera' *Idiognathodus* or *Streptognathodus*, *Ozarkodina*, *Hindeodella* and *Synprioniodina*." The name originally proposed for this assemblage, *Scottella* Rhodes, 1952, pp. 890–891 is preoccupied as pointed out by Rhodes (1953*a*, p. 612).

S. typicus (Rhodes) 1952, pp. 891–895, pl. 126, figs. 1–11, pl. 127, figs. 1–25. Upper Pennsylvanian, Illinois. "Natural assemblages made up of one pair of *Idiognathus* or *Streptognathus*, one pair of *Ozarkodina*, one pair of *Synprioniodina* and four pairs of *Hindeodella* (which) are arranged in an elongated paired series...."

NEW NAMES
Disjunct Units

Drepanodus homocurvatus Lindström 1954, p. 563, new name for *Oistodus curvatus* Branson and Mehl, 1933, p. 110, pl. 9, figs. 4, 10, 12.

Kladognathus Rexroad, 1958, p. 19, new name for *Cladognathus* Rexroad, 1957, p. 28 which is preoccupied by *Cladognathus* Burmeister, 1847.

Ptiloconus Sweet, 1955, pp. 245–246, new name for *Pteroconus* Branson and Mehl, 1933, p. 99, which is preoccupied.

Assemblages

Scottognathus Rhodes, 1953a, p. 612, new name for *Scottella* Rhodes, 1952, pp. 890–891, which is preoccupied.

S. typicus (Rhodes) 1952, pp. 891–895, pl. 126, figs. 1–11, pl. 127, figs. 1–25, new name for *Scottella typica* Rhodes, 1952.

HOMONYMS AND SYNONYMS
Disjunct units

Cladognathus Rexroad, 1957, p. 28, preoccupied by *Cladognathus* Burmeister, 1847. Renamed *Kladognathus* by Rexroad, 1958, p. 19.

Oistodus gracilis Lindström, 1954, p. 576, preoccupied by *Oistodus gracilis* Branson and Mehl, 1933.

O. triangularis Lindström, 1954, p. 581, preoccupied by *Oistodus? triangularis* Furnish, 1938.

Pteroconus Branson and Mehl, 1933, pp. 111–112, preoccupied by *Pteroconus* Green, 1900. Renamed *Ptiloconus* by Sweet, 1955a, pp. 245–246.

Rosagnathus Rhodes, 1955, p. 128, junior synonym of *Tetraprioniodus* Lindström, 1954, p. 596.

Assemblages

Scottella Rhodes, 1952, pp. 890–891, preoccupied by *Scottella* Enderlein, 1910. Renamed *Scottognathus* by Rhodes, 1953a, p. 612.

INDEX OF CONODONT-BEARING FORMATIONS

The names of conodont-bearing formations and faunal zones mentioned in the published articles listed in the bibliography are indexed here. The formations and faunal zones are listed alphabetically under the appropriate geologic system together with the name of the author and the publication date of the articles which indicate that the unit contains conodonts. An asterisk (*) precedes the publication date of articles which include faunal lists for the indicated formation or zone.

LOWER PALEOZOIC (UNDIVIDED)

Unnamed formation: Australia – Crespin, 1958.

UPPER CAMBRIAN

Agnostus limestone: Germany – Müller, 1956*d*.
Deadwood formation: South Dakota – Müller, 1956*d*.
Olenus limestone: Germany – Müller, 1956*d*.
Signal Mountain limestone: Oklahoma – Branson, 1957*a*; Müller, 1956*d*.
Unnamed limestone from the *Conaspis* zone: Utah – Müller, 1956*d*; Wyoming – Müller, 1956*d*.

ORDOVICIAN (UNDIVIDED)

Unnamed formation: Argentina – Boltovskoy, 1955; Michigan Basin – Kesling, 1958; Sweden – Brotzen, 1953; Tennessee – Lalicker, 1950.

LOWER ORDOVICIAN

Carlton group: Western Australia – Traves, 1955.
Ceratopyge limestone: Sweden – Tjernvik, 1956.
Dead Horse conglomerate member of the Manitou formation: Colorado – Bass and Northrop, *1953, 1955; Zapp, 1957.
Dictyonema shales: Estonia – Scupin, 1928; Sweden – Hede, 1951.
Döbrasandstein: Germany – Sannemann, *1955*c*; Wurm, 1956, 1957.
Dutchtown formation: Missouri – Ørvig, *1958.
Ellenburger group: Texas – Hendricks, 1952.
Emanuel formation: Western Australia – Glenister and Glenister, *1958.
Glaukonitsand: Estonia – Lindström, *1954; Scupin, 1928.
Grünsand: Estonia – Schmidt, 1897.
Limbata limestone: Sweden – Lindström, *1954; Tjernvik, 1956.
Lower *Dicellograptus* shales: Sweden – Hede, 1951; Lindström, *1955*a*; Nilsson, 1951.
Lower *Didymograptus* shales: Sweden – Hede, 1951; Nilsson, 1951.
Lower *Planilimbata* limestone: Sweden – Lindström, *1954; Tjernvik, 1956.
Manitou formation – see Dead Horse conglomerate member.
Marathon limestone: Texas – Lindström, *1954; Rhodes, 1953*b*.
Mittlerer Eisenerzhorizont: Germany – Bachmann, *1954.
Obolus sandstone: Estonia – Opik, 1929, 1956; Scupin, 1928.
Obolus conglomerate: Sweden – Waern, 1953.
Oneota member of the Prairie du Chien group: Iowa – Thomas and Balster, *1949; Minnesota – Lindström, *1954.
Pander Greensand: Western Australia – McWhae, Playford, and others, *1958; Traves, *1955.
Platyurus limestone: Sweden – Lindström, *1955*a*.
Prairie du Chien formation – see Oneota member.
Randschieferserie: Germany – Sannemann, *1953, *1955*c*; Wurm, 1956, 1957.
Rockdale Run formation: Pennsylvania – Sando, *1958.
Roebuck dolomite: Western Australia – Glenister and Glenister, *1958; McWhae, Playford, and others, *1958.
Schroeteri limestone: Sweden – Lindström, *1955*a*.
Stonehenge limestone – see Stoufferstown member.
Stoufferstown member of the Stonehenge limestone: Pennsylvania – Sando. *1958.
Ungulite sandstone: Estonia – Lindström, 1954.
Unterer Erzhorizont und Phycodenquarzit: Germany – Bachmann, *1954.
Upper *Didymograptus* shale – listed under Middle Ordovician.
Upper *Planilimbata* limestone: Sweden – Lindström, *1954; Tjernvik, 1956.
Unnamed formations: Argentina – Youngquist and Iglesias, *1951; Estonia – Lindström, *1954; Scotland – Lamont and Lindström, *1957, Hessland, 1958; Sweden – Brotzen, 1953, Hessland, 1958, Lindström, *1957, Waern, 1953.
Valmy formation: Nevada – Ross, 1958.
Zone of *Ceratopyge forficula:* Sweden – Lindström, 1954.
Zone of *Didymograptus balticus:* Sweden – Lindström, 1957.

MIDDLE ORDOVICIAN

Aladdin sandstone: South Dakota – McCoy, 1958; Wyoming – McCoy, 1958.
Bromide formation: Oklahoma – Amsden, *1957*a*.
Carimona member of the Platteville formation: Minnesota – Weiss, 1955.
Decorah formation – see Guttenburg member.
Döbrasandstein – listed under Upper Ordovician.
Emanuel formation: Western Australia – Glenister and Glenister, 1958.
Fort Peña limestone: Texas – Rhodes, 1953*b*; West Texas Geological Society, 1952.
Galena group: Upper Mississippi Valley – Echols, 1957.
Glenwood formation: Minnesota – Rhodes, 1953*b*; Upper Mississippi Valley – Thompson, 1953.
Guttenburg member of the Decorah formation: Iowa – Thomas and Balster, *1949.
Harding formation: Colorado – Denison, 1956, Fredericksson and Pollack, 1952, Loeblich, 1955, 1956, Sweet, 1954, 1955*a*, *1955*b*, Thompson, 1953.
Ice Box shale: Montana – McCoy, 1958, Randall, 1958; South Dakota – McCoy, 1952, 1958, Randall, 1958; Wyoming – McCoy, 1958, Randall, 1958.
Joins formation of the Simpson group: Oklahoma – Harris, *1957.
Larapintine series: Central Australia – Crespin, 1956.
Llandeilo limestone: England – Rhodes, *1953*b*.
Martinsburg shale: New Jersey – Ethington, Furnish, and Markewicz, *1958.
McLish formation of the Simpson group: Oklahoma – Amsden, *1957*a*.
Oberer Eisenerzhorizont: Germany – Bachmann, *1954.
Oil Creek formation of the Simpson group: Oklahoma – Amsden, *1957*a*.

Platteville formation: Illinois – Gutschick, 1954; Iowa – Thomas and Balster, *1949; Minnesota – Weiss, 1955. Also see Specht's Ferry member.
Plattin limestone: Missouri – Rhodes, 1953*b*.
Randschieferserie – listed under Lower Ordovician.
Roughlock siltstone: Montana – McCoy, 1958; Randall, 1958; South Dakota – McCoy, 1952, Randall, 1958; Wyoming – McCoy, 1958, Randall, 1958.
Simpson group – see Joins formation, Oil Creek formation, McLish formation, Tulip Creek formation.
Specht's Ferry member of the Platteville formation: Iowa – Thomas and Balster, *1949.
Tulip Creek formation of the Simpson group: Oklahoma – Amsden, *1957*a*; Harris, *1957.
Unnamed formation: Montana – Leatherock, 1950; Scotland – Lamont and Lindström, *1957, Ethington, Furnish, and Markewicz, 1958; Sweden – Lamont and Lindström, *1957, Ethington, Furnish, and Markewicz, 1958.
Upper *Didymograptus* shales: Sweden – Hede, 1951; Nilsson, 1951.
Viola limestone: Oklahoma – Amsden, *1957*a*.
Winnipeg formation – listed under Upper Ordovician.
Woods Hollow shale: Texas – West Texas Geological Society, 1952.

UPPER ORDOVICIAN

Arnheim formation – see Oregonia member and Sunset member.
Black Trataspis shale: Sweden – Henningsmoen, *1948.
Brainard limestone member of the Maquoketa formation: Iowa – Glenister, A. T., *1957.
Brainard shale member of the Maquoketa formation: Iowa – Glenister, A. T., *1957.
Burnam limestone: Texas – Barnes, Cloud, and Duncan, 1953.
Clermont member of the Maquoketa formation: Iowa – Glenister, A. T., *1957.
Döbrasandstein: Germany – Sannemann, *1955*c*; Wurm, 1956, 1957.
Eden group: Ohio – Kesling, 1957, 1958.
Elgin member of the Maquoketa formation: Iowa – Glenister, A. T., *1957.
Elkhorn formation: Indiana – Branson, Mehl, and Branson, *1951.
Fort Atkinson member of the Maquoketa formation: Iowa – Glenister, A. T., *1957.
Gelli-grin limestone: England – Rhodes, *1953*b*.
Keisley limestone: England – Barnard, 1953; Rhodes, *1955.
Liberty formation: Kentucky and Indiana – Branson, Mehl, and Branson, *1951.
Lower Hartfell shale: Scotland – Lindström, *1957.
Maquoketa formation: Iowa – Branson, 1957*b*, Echols, 1958, Tasch, *1958; Missouri – Echols, 1958, Rhodes, *1953*b*, Tasch, *1958, Werner and Echols, 1958. *Also see* Brainard limestone member, Brainard shale member, Clermont member, Elgin member, Fort Atkinson member, and Phosphatic member.
Maysville group: Ohio – Kesling, 1958.
Oregonia member of the Arnheim formation: Kentucky – Branson, Mehl, and Branson, *1951.
Pen-y-garnedd limestone: England – Rhodes, *1953*b*.
Phosphatic member of the Maquoketa formation: Iowa – Glenister, A. T., *1957.
Randschieferserie – listed under Lower Ordovician.
Sunset member of the Arnheim formation: Kentucky – Branson, Mehl, and Branson, *1951.
Thebes formation: Missouri – Rhodes, *1953*b*.
Unnamed formation: Iowa – Echols, 1957. Ohio – Loeblich, 1955.
Waynesville formation: Indiana – Branson, Mehl, and Branson, *1951. Kentucky – Branson, Mehl, and Branson, *1951.
Whitewater formation: Indiana – Branson, Mehl, and Branson, *1951.
Winnipeg sandstone: Montana – Ørvig, 1958. North Dakota – Echols, 1957, Holland and Waldren, *1955, Strassburg, *1954.

SILURIAN (UNDIVIDED)

Unnamed formation: England – Barnard, 1957.

LOWER SILURIAN

Chimneyhill formation – see Cochrane member.
Cochrane member of the Chimneyhill formation: Oklahoma – Amsden, 1957*b*.
Orthoceratenkalk – listed under Upper Silurian.

MIDDLE SILURIAN

Bainbridge limestone – listed under Upper Silurian.
Betikum von Málaga – see "Calizas alabeadas."
"Calizas alabeadas" (Santi Petri-Kalk): Spain – Kockel, *1958.
Chimneyhill formation – see Clarita member.
Clarita member of the Chimneyhill formation: Oklahoma – Amsden, 1957*b*.
Dirk Hartog limestone: Western Australia – Glenister and Glenister, *1957, McWhae, Playford, and others, *1958.
Fusselman limestone: Texas – Secor, 1958.
Henryhouse formation: Oklahoma – Amsden, 1957*b*.
Unnamed formation: Algeria – Mutvei, 1956. Illinois – Jones, D. J., 1958*b*.
Wenlock limestone: England – Ireland, 1958.

UPPER SILURIAN

Aymestry limestone: England – Ireland, 1958; Rhodes, *1953*b*.
Bainbridge limestone: Missouri – Boucot, *1958.
Betikum von Málaga – listed under Lower Silurian.
Beyrichienkalk: Germany – Gross, *1957.
"Calizas alabeadas" (Santi Petri-Kalk) – listed under Lower Silurian.
Elbersreuther Kalk – see Orthoceratenkalk.
Hunton group: Oklahoma – Echols, 1958.
Ludlow Bone bed: England – Barnard, 1956; Denison, 1956.
Orthoceratenkalk: Germany – Bischoff and Sannemann, *1958, Sannemann, *1954, Walliser, *1957.
Schichtlücke: Germany – Sannemann, *1954.
Unnamed formation: Algeria – Mutvei, 1956. Ösel Island – Gross, *1954.
Upper Ösel group (K_1): Ösel Island – Denison, 1956.

DEVONIAN (UNDIVIDED)

Unnamed formation: Australia – Echols, 1957; Colorado – Levinson, 1955; England – Barnard, 1953, 1957; Mississippi Valley – Scott, 1957; Missouri – Echols, 1958; Montana – Levinson, 1955; Nevada – Ro-

berts, Hotz, and others, 1958; New Mexico – Levinson, 1955; Texas – Ellison and Wynn, 1950, Levinson, 1955, 1957; Wyoming – Levinson, 1955.

LOWER(?) DEVONIAN

Unnamed formation: Missouri – Echols, 1956.

LOWER DEVONIAN

Betikum von Málaga – see "Calizas alabeadas."
"Calizas alabeadas" (Santi Petri-Kalk): Spain – Kockel, *1958. Also listed under Middle Silurian.
Heisdorfer Schichten: Germany – Bischoff and Ziegler, *1957, Ziegler, *1956.
Pendik-Kalk Serie: Turkey – Ziegler, *1956.
Princeps-Kalk: Germany – Bischoff and Ziegler, *1957; Ziegler, *1956.
Schichtlücke: Germany – Sannemann, *1954.
Schönauer Kalk: Germany – Bischoff and Ziegler, *1957, Ziegler, *1956, 1958*a*.
Steinberger Kalk: Germany – Ziegler, *1956.
Tentakulitenkalk: Germany – Bischoff and Sannemann, *1958, Sannemann, *1954.
Unnamed formation: Texas – Jones, T. S., 1953.
Zorgensis-Kalk: Germany – Ziegler, *1956.

MIDDLE DEVONIAN

Amplexus-Kalk: Germany – Bischoff and Ziegler, *1957.
Arkona shale: Ontario – Stumm and Wright, *1958.
Ballersbacher Kalk: Germany – Bischoff and Ziegler, *1957.
Betikum von Málaga – listed under Lower Devonian.
"Bonebeds": Ohio – Stewart and Sweet, *1956.
Buchenauer Schichten: Germany – Bischoff, 1955; Krebs, *1958, Stoppel and Ziegler, *1958.
Caballos novaculite (upper chert member): Texas – Graves, *1952, Jones, T. S., 1953, Murchison, 1958, West Texas Geological Society, 1952.
"Calizas alabeadas" (Santi Petri-Kalk) – listed under Lower Devonian.
Cedar Valley limestone – see Coralville member, Rapid member, and Solon member.
Columbus limestone: Ohio – Stewart and Sweet, *1956.
Coralville member of the Cedar Valley limestone: Iowa – Thomas and Balster, *1949.
Delaware limestone: Ohio – Stewart, *1950; Stewart and Sweet, *1956.
Flinzkalke: Germany – Bischoff and Ziegler, *1957, Reichstein, *1958.
Greifensteiner Kalk: Germany – Bischoff and Ziegler, *1957.
Günteröder Kalk: Germany – Bischoff and Ziegler, *1957.
Hauptquarzit: Germany – Reichstein, *1958.
Hungry Hollow formation: Ontario – Stumm and Wright, *1958.
Hüttenröder Schichten: Germany – Reichstein, *1958.
Kalkige Zwischenschichten: Germany – Bischoff and Ziegler, *1957.
Ludlowville formation: New York – Smith, 1956.
Nevada limestone equivalent: Nevada –Berdan, 1953.
Odershäuser Kalk: Germany – Bischoff and Ziegler, *1957.
Padberger Kalk: Germany – Bischoff and Ziegler, *1957.
Rapid member of the Cedar Valley limestone: Iowa – Downs and Youngquist, *1950.
Schichtlücke – listed under Lower Devonian.
Solon member of the Cedar Valley limestone: Illinois – Collinson and Scott, *1958*a*.
Sparganophyllum Kalk: Germany – Bischoff and Ziegler, *1957.
Tentakulitenkalk – listed under Lower Devonian.
Unnamed formation: Algeria – Lys and Serre, *1957*a*, *1957*c*; England – Barnard, 1953; Dineley and Rhodes, *1956; Germany – Beckmann, *1953, Bischoff and Ziegler, *1957, Ziegler, *1958*b*; Nevada – Roberts, Hotz, and others, 1958; Ohio – Loeblich, 1956, Todd, 1952; Wyoming – Blackstone and McGrew, *1954.
Widder formation: Ontario – Stumm and Wright, *1958.
Wirbelauer Kalk: Germany – Bischoff and Ziegler, *1957.

UPPER DEVONIAN

Acker-Bruchbergschichten: Germany – Schwan, *1958.
Adorf-Stufe: Germany – Stoppel, *1958*b*, Ziegler, *1958*b*.
Adorfer Kalk: Germany – Müller, *1956*c*; Rabien, 1956.
Amana beds: Iowa – Müller, 1956*b*; Müller and Müller, *1957.
Antrim shale: Michigan – Hass, *1958*b*.
Arkansas novaculite: Arkansas – Hass, 1951, *1956*a*, *1958*b*, Müller and Müller, 1957; Oklahoma – Hass, 1951; Tennessee – Reed, Schoff, and Branson, 1955.
Aubach-Tuffen: Germany – Wiegel, 1956.
Bomben-Schalstein: Germany – Wiegel, *1956.
Buchenauer Schichten – listed under Middle Devonian.
Buntschieferzone: Germany – Reichstein, 1958; Schriel and Stoppel, *1958.
Caballos novaculite – listed under Middle Devonian.
Cerro Gordo member of the Lime Creek formation: Iowa – Thomas and Balster, 1949.
Chagrin shale member of the Ohio shale: Ohio – Todd, 1953.
Chappel formation – see King Creek marl member.
Chattanooga shale: Cincinnati – Nashville arch and Ozark dome – Rich, 1953; Mississippi – Hass, *1954, *1956*b*, Mellen, *1955; Oklahoma – Hass, *1956*b*, Huffman and others, 1958, Lantz and Fitts, 1951; Tennessee – Hass, *1953*b*, *1956*b*, *1958, Loeblich, 1955, 1956, 1957, Todd, 1952.
Cheiloceras zone (to II): Germany – Müller, *1956*c*. Spain – Müller, *1956*c*.
Cleveland member of the Ohio shale: Ohio – Todd, 1953.
Clymenien-Kalk: Germany – Müller, *1956*c*.
Conodont limestone member of the Genesee group: New York – Hibbard, *1951.
Darby formation: Wyoming – Klapper, *1958.
Dasberger Kalk: Germany – Müller, *1956*c*.
Dasbergstufe: Germany – Bender, *1958; Rabien, 1956; Stoppel, *1958*b*.
Dillenburger Tuffe: Germany – Krebs, *1958.
Doublehorn shale member of the Houy formation: Texas – Cloud, Barnes, and Hass, *1957; Williams, H. L., 1958*b*.
Dowelltown member of the Chattanooga shale: Tennessee – Hass, *1956*b*.
Dunkirk shale member of the Perrysburg formation: New York – Colton, 1956, deWitt, 1956, deWitt and Colton, 1953.

Ellicott shale: New York – Hass, *1958*b*.
Exshaw formation: Alberta – Harker and Raasch, *1958, Loranger, 1958, Raasch, 1958.
Flaserkalke: Germany – Wiegel, *1956.
Flinzkalke – listed under Middle Devonian.
Gassaway member of the Chattanooga shale: Tennessee – Hass, *1956*b*.
Gemarkungsgrenze: Germany – Müller, *1956*c*.
Genesee group: New York – Clarke, 1891; Hibbard, *1951; North America – Müller, 1956*b*. Also see Conodont limestone member.
Geneseo shale – see Genundewa limestone lentil.
Genundewa limestone lentil of the Geneseo shale: New York – deWitt, 1956, deWitt and Colton, 1953, Hass, 1958*b*.
Gneudna formation: Western Australia – McWhae, Playford, and others, *1958.
Gogo formation of the Mount Pierre group: Western Australia – McWhae, Playford, and others, *1958.
Gowanda member of the Perrysburg formation: New York – Hass, *1958*b*.
Grassy Creek shale: North America – Müller, 1956*b*.
Hackberry shale: North America – Müller, 1956*b*.
Hangender Wetzschieferhorizont: Germany – Schriel and Stoppel, *1958.
Hangendste Schicht des Kalkes aus der Schieferserie: Germany – Müller, 1956*c*.
Hanover shale: New York and Pennsylvania – Hass, *1958*b*. Also see Pipe Creek member.
Hauptkieselschiefer: Germany – Schriel and Stoppel, *1958.
Hellekieselschiefer series: Germany – Sannemann, *1955*b*.
Hemberg-Stufe: Germany – Bender, *1958, Rabien, 1956, Stoppel, *1958*b*.
Houy formation – see Doublehorn shale member, Ives breccia member, and Phosphoritic member.
Hunnacker Kalkes: Germany – Wiegel, *1956.
Huron shale: Kentucky – Hass, *1956*b*. Ohio – Hass, *1956*b*.
Iberger Kalk: Germany – Beckmann, 1949; Walliser, *1958*b*.
Independence shale: Iowa – Hilterman, 1958, Müller, 1956*b*, Müller and Müller, *1957.
Ives breccia member of the Houy formation: Texas – Cloud, Barnes, and Hass, *1957, Williams, H. L., 1958*d*.
Kalk der Hembergschichten: Germany – Müller, *1956*c*.
Kellwasserkalk: Germany – Müller, *1956*c*, Rabien, 1956, Ziegler, *1958*b*.
Keratophyr-Eruptivbrekzie: Germany – Bischoff and Sannemann, *1958.
King Creek marl member of the Chappel formation: Texas – Arant, 1958.
Lime Creek formation – see Cerro Gordo member.
Lower Grenzkalk: Germany – Müller, *1956*c*.
Lower Pilton beds: England – Dineley and Rhodes, *1956.
Manticoceras zone: Germany – Bischoff and Ziegler, *1957, Müller, *1956*c*; Western Australia – Müller, *1956*c*, Glenister, B. F., 1958.
Maple Mill shale: Iowa – Müller, 1956*b*; Müller and Müller, 1957.
Maury formation: Tennessee – Hass, *1953*b*, 1956*b*, Loeblich, 1955, 1956, 1957.
Middlesex shale: New York – Colton, 1956, deWitt, 1956.
Mount Pierre group – see Gogo formation.
Naples group: New York – Clarke, 1891, Hibbard, *1951.
Nehden Stufe: Germany – Bender, *1958, Stoppel, *1958*b*.
Nehdener Schiefer: Germany – Müller, *1956*c*.
New Albany shale: North America – Müller, 1956*b*; Cincinnati – Nashville arch and Ozark dome – Rich, 1953.
Northeast shale: Pennsylvania – Hass, *1958*b*.
North Liberty beds: Iowa – Müller and Müller, *1957.
Obere Matagne-Schichten: Germany – Müller, *1956*c*.
Ohio shale: Cincinnati – Nashville arch and Ozark dome – Rich, 1953; Ohio – Müller, 1956*b*, Todd, 1953. Also see Chagrin member and Cleveland member.
Olentangy shale: Ohio – Müller and Müller, 1957.
Onondaga limestone: Ontario – Hibbard, 1951.
Oxyclymenia zone: Germany – Müller, *1956*c*.
Oxyclymenia or *Wocklumeria* zone: Austria – Müller, *1956*c*; Germany – Müller, *1956*c*; Italy – Müller, *1956*c*; Silesia – Müller, *1956*c*.
Percha shale: New Mexico – Jicha, 1954, Kottlowski, Flower, Thompson, and Foster, 1956.
Perrysburg formation – *see* Dunkirk shale member, Gowanda member, and South Wales member.
Phosphoritic member of the Houy formation: Texas – Cloud, Barnes, and Hass, *1957.
Pilot shale: Nevada – Nolan, Merriam, and Williams, *1956.
Pilton beds: England – Barnard, 1953.
Pipe Creek member of the Hanover shale: New York – Colton, 1956.
Platyclymenia zone: Germany – Müller, *1956*c*.
Portal formation: Arizona – Sabins, *1957.
Prolobiteskalk: Germany – Müller, *1956*c*.
Rhinestreet shale member of the West Falls formation: New York – Colton, 1956, deWitt, 1956, deWitt and Colton, 1953, Hibbard, *1951.
Serie der hellen Kieselschiefer: Germany – Sannemann, *1953, Schriel and Stoppel, *1958, Wurm, *1956, 1957.
Sessackerschurfbänke: Germany – Ziegler, *1958*b*.
Sheffield shale: Iowa – Müller and Müller, *1957, Thomas and Balster, *1949.
Shumla sandstone: New York – Hass, *1958*b*.
Sicheres (to I^{α}): Germany – Müller, *1956*c*.
Sly Gap formation: New Mexico – Kottlowski, Flower, Thompson, and Foster, 1956.
South Wales member of Perrysburg formation: New York – Hass, *1958*b*.
Squaw Bay limestone: Michigan – Müller and Müller, 1957.
Sweetland Creek shale: Iowa – Müller, 1956*b*, Müller and Müller, 1957, Thomas, *1950, Thomas and Balster, *1949.
Tentakulitenkalk – listed under Lower Devonian.
Threeforks shale: Wyoming – Blackstone and McGrew, *1954*a*, *1954*b*.
Unit "C": Montana – Clark, L. M., 1954, Harker, Hutchinson, and McLaren, 1954; McLaren, 1954.
Unnamed formation: Alabama – Peck, 1953, Algeria – Lys and Serre, *1957*a*, *1957*c*; Austria – Flügel and Ziegler, *1957, Müller, *1956*c*; England – Barnard, 1953, Dineley and Rhodes, *1956, Rhodes and Dineley, *1957*a*; France – Lys and Serre, *1957*b*, Lys, Serre, and Deroo, *1957; Germany – Beckmann, *1953, Bischoff, *1957, Müller, *1956*c*, Rabien and Rabitz, *1958, Sannemann, *1955*a*, Schriel and Stoppel, *1958, Stoppel, *1958*b*, Ziegler, 1958*a*, *1958*b*; Missouri – Peck, 1953; Nevada

– Roberts, Hotz, and others, 1958; New York – Loeblich, 1955, 1956, Douglass, 1958; Pennsylvania–Loeblich, 1955; Spain – Müller, *1956*c*; Tennessee – Peck, 1953; Western Australia – McWhae, Playford, and others, *1958, Müller, *1956*c*.

Unterer Grenzkalk: Germany – Müller, *1956*c*.

Unterer Plattenkalk: Germany – Müller, *1956*c*.

Urfer Schichten: Germany – Bischoff and Ziegler, *1956.

Virgin Hills formation: Western Australia – McWhae, Playford, and others, *1958.

West Falls formation – see Rhinestreet shale member.

Westfield shale: New York – Hass, *1958*b*.

Wiscoy sandstone: New York – Hass, *1958*b*.

Wocklumer Kalk: Germany – Müller, *1956*c*.

Wocklumeria zone: Austria – Müller, *1956*c*; Germany – Bischoff, *1957, Müller, *1956*c*, Rabien, 1956.

Woodford shale: Texas – Ellison, 1949, 1950, Jones, T. S., 1953, Singletary, 1958; New Mexico – Ellison, 1949, *1950; Oklahoma – Hass, *1958*b*, Wilson, L. R., 1958.

DEVONIAN – MISSISSIPPIAN (UNDIVIDED)

Phosphoritic member of the Houy formation – listed under Upper Devonian.

Unnamed formation: Alabama – Peck, 1953; Germany – Rabien and Rabitz, *1958; Missouri – Peck, 1953; Tennessee – Peck, 1953; Texas – Barnes, Cloud, and Duncan, *1953.

CARBONIFEROUS (UNDIVIDED)

Unnamed formation: Egypt – Tromp, 1952; England – Barnard, 1953; Scotland – Barnard, 1953, 1956.

LOWER CARBONIFEROUS

Erdbacher Kalk: Germany – Walliser, *1958*b*.

Gattendorfia-Stufe (cu I): Germany – Bischoff, *1957.

Gnathodus-Kalke: Austria – Flügel and Ziegler, 1957.

Goniatites-Stufe (cu III): Germany – Bender, *1958, Bischoff, *1957.

Kulm II-Kalk: Germany – Bischoff and Ziegler, 1956.

Kulmkieselschiefer: Germany – Schwan, *1958.

Laurel beds: Western Australia – McWhae, Playford, Lindner, Glenister, and Balme, *1958.

Pericyclus-Stufe (cu II): Germany – Bischoff, *1957.

Rhenaer-Kalk: Austria – Flügel and Ziegler, 1957.

Schiffelborner Schichten: Germany – Bischoff and Stoppel, *1957.

Steinberg Kalke: Austria – Flügel and Ziegler, 1957.

Unnamed formation: Germany – Bischoff and Ziegler, 1956, Stoppel, *1958*b*, Walliser, *1958*b*.

Urfer Schichten: Germany – Bischoff and Ziegler, *1956.

MISSISSIPPIAN (UNDIVIDED)

Unnamed formation: Illinois – Loeblich, 1955; Iowa – Loeblich, 1955; Mississippi Valley – Douglass, 1958, Loeblich, 1956, Scott, 1957; Missouri – Echols, 1957, Loeblich, 1955, Stainforth, 1956; Texas – Ellison, 1950.

LOWER MISSISSIPPIAN (Kinderhook)

Acker-Bruchbergschichten: Germany – Mempel, 1950, Schwan, 1950, *1958.

Arkansas novaculite: Arkansas – Hass, 1951, *1956*a*; Oklahoma – Hass, 1951. Also listed under Upper Devonian.

Barnett formation – listed under Middle Mississippian.

Black Rock limestone: England – Dineley and Rhodes, *1956. Also see "Fish bed" and Horizon γ.

Bushberg sandstone: Missouri – Echols, 1955.

Chappel limestone: Texas – Cloud, Barnes, and Hass, 1957, Douglass, 1958, Loeblich, 1955, 1956, 1957.

Chouteau formation: Illinois – Collinson and Scott, *1958*b*, Benson and Collinson, 1958.

"Fish bed" in the Black Rock limestone: England – Dineley and Rhodes, 1956.

Grassy Creek shale: Illinois – Williams, J. S., 1957; Iowa – Williams, J. S., 1957; Missouri – Williams, J. S., 1957.

Grauwacken series of the Acker-Bruchbergschichten: Germany – Schwan, 1950.

Hannibal formation: Illinois – Benson and Collinson, 1958, Collinson and Scott, *1958*b*.

Horizon γ in the Black Rock limestone: England – Dineley and Rhodes, *1956.

Little Chief Canyon member of the Lodgepole limestone: Montana – Knechtel, Smedley, and Ross, 1954; Mickelson, 1956.

Lodgepole limestone – see Little Chief Canyon member.

Louisiana limestone: Illinois – Williams, J. S., 1957; Iowa – Williams, J. S., 1957; Missouri – Williams, J. S., 1957.

Lower limestone shale group: England – Dineley and Rhodes, *1956.

Lower Pilton beds: England – Dineley and Rhodes, *1956.

Maury formation: Tennessee – Hass, *1953*b*, *1956*b*, Loeblich, 1955, 1956, 1957.

Sappington formation: Montana – Jones, D. J., 1958*a*.

Shirehampton beds: England – Dineley and Rhodes, 1956.

Sunbury shale: Ohio – Bucher, 1929.

Sylamore sandstone: Missouri – Kaiser, 1950.

Unnamed formation: Alabama – Peck, 1953. Algeria – Lys and Serre, *1957*a*; Germany – Bischoff, *1957; Missouri – Echols, 1958, Peck, 1953; Tennessee – Peck, 1953.

Wassonville limestone: Iowa – Thomas and Balster, 1949, Youngquist and Downs, *1951.

Welden limestone: Oklahoma – Peck, 1953.

MIDDLE MISSISSIPPIAN (Osage and Meramec)

Barnett formation: Texas – Cloud, Barnes, and Hass, 1957; Elias, *1956*a*; Hass, *1953*a*; Rexroad, 1956; Williams, H. L., 1958*a*.

Burlington limestone: Iowa – Youngquist, Miller, and Downs, *1950.

Caney shale: Oklahoma – Hass, 1950. Also see Delaware Creek member and Sand Branch member.

Chappel limestone – listed under Lower Mississippian.

Delaware Creek member of the Caney shale: Oklahoma – Elias, *1956.

Grauwacken series of the Acker-Bruchbergschichten – listed under Lower Mississippian.

Maury formation – listed under Lower Mississippian.

Osage group: Iowa – Thomas and Balster, 1949.

Reeds Spring limestone: Missouri – Echols, 1957; Peck, 1953.

Saint Louis limestone: Iowa – Thomas and Balster, 1949.

Sand Branch member of the Caney shale: Oklahoma – Elias, *1956.

Spirit Hill limestone of the Weaber group: Western Australia – McWhae, Playford, Lindner, and others, *1958.

Springville shale – *see* State Pond member.
Stanley shale – listed under Upper Mississippian.
State Pond member of the Springville shale: Illinois – Benson and Collinson, 1958; Collinson and Scott, *1958*b*.
Unnamed formation: Algeria – Lys and Serre, *1957*a*, *1957*c*; France – Lys, Serre, and Deroo, 1957.
Weaber group – *see* Spirit Hill limestone.

UPPER MISSISSIPPIAN (Chester)

Barnett formation – listed under Middle Mississippian.
Caney shale – listed under Middle Mississippian.
Chester series: Illinois – Rexroad, *1956, *1957.
Clore formation: Illinois – Rexroad, *1957.
Glen Dean formation: Illinois – Rexroad, *1957, 1958; Indiana – Rexroad, *1958; Kentucky – Rexroad, *1958.
Goddard shale: Oklahoma – Elias, *1956.
Golconda formation: Illinois – Rexroad, *1957.
Griottes: Spain – Lys and Serre, *1958.
Heath shale: Montana – Elias, *1956.
High Resistivity shale: Mississippi – Stanley, *1958.
Kinkaid formation: Illinois – Rexroad, *1957.
Menard formation: Illinois – Rexroad, *1957.
Paint Creek formation: Illinois – Rexroad, *1957.
Pella beds: Iowa – Rexroad, *1956; Youngquist and Miller, *1949.
Pitkin limestone: Arkansas – Rexroad, 1956; Oklahoma – Rexroad, 1956.
Renault formation: Illinois – Rexroad, *1957.
Rhenaer Kalk: Austria – Flügel and Ziegler, *1957.
Sand Branch member of the Caney shale – listed under Middle Mississippian.
Scottish Carboniferous limestone series – see Top Hosie shale.
Stanley shale: Arkansas – Hass, *1950, *1956*a*; Oklahoma – Hass, *1950.
Top Hosie shale of the Scottish Carboniferous limestone series: Scotland – Craig, 1952, *1954.
Unnamed formation: Algeria – Lys and Serre, *1957*a*, *1957*c*; France – Lys, Serre, and Deroo, 1957; Germany – Bischoff, *1957; Mississippi – Hass, *1954; Missouri – Lalicker, 1950; Scotland – Craig, 1952.
Vienna formation: Illinois – Rexroad, *1957.
Chewelah argillite: Washington – Enbysk, 1956.

CARBONIFEROUS (Namurian)

Colsterdale Marine Band: England – Dunham and Stubblefield, 1945.
Edale Shales: England – Dineley and Rhodes, 1956.
Edendork Beds: Northern Ireland – Robbie, 1955.
Millstone Grit: England – Dunham and Stubblefield, 1945; Mitchell, 1954; Rhodes, 1953*b*; Stevenson and Mitchell, 1955.
Pilton Beds: England – Barnard, 1953.
Rossmore Mudstone: Northern Ireland – Fowler, 1955.

PENNSYLVANIAN (UNDIVIDED)

Unnamed formation: Montana – Stainforth, 1956; New Mexico – Thompson and Kottlowski, 1955.

LOWER PENNSYLVANIAN

Alton Marine Band: England – Eden, *1954.
Bullion Mine Marine Band: England – Magraw, *1957.
Cannel Mine Marine Band: England – Magraw, *1957.
Cefn Coed Marine Band: England – Ramsbottom, *1952.
Charles Marine Band: England – Mitchell, *1954; Mitchell, Stubblefield, and Crookall, *1945; Stubblefield and Calver, *1955.
Clown Marine Band: England – Edwards, 1954.
Ditton Marine Band: England – Magraw, *1957.
Fair Oak Marine Band: England – Mitchell, Stubblefield, and Crookall, *1945.
Finefrau Nebenbank: Germany – Schmidt and Teichmüller, *1955; Netherlands – Demanet, *1949, Fiebig, 1955.
Forty-Yards Coal: England – Eden, *1954.
Gastrioceras subcrenatum Marine Band: England – Eden, *1954; Stubblefield and Calver, *1955.
Glen Eyrie shale: Colorado – Maher and Collins, 1952; McLaughlin, *1952.
Jackfork sandstone: Oklahoma – Hass, 1950.
Kendrick shale: Kentucky – Summerson and Campbell, 1958.
Lower Foot Marine Band: England – Magraw, *1957.
Lower Mercer marine limestone: Ohio – Marple, 1951.
Loxley Edge Rock: England – Eden, *1954.
Marble Falls limestone: Texas – Levinson, 1953.
Norton Marine Band: England – Eden, *1954.
Nuneaton Marine Band: England – Mitchell, Stubblefield, and Crookall, *1942.
Overseal Marine Band: England – Mitchell and Stubblefield, *1941.
Pot Clay Marine Band: England – Eden, *1954.
Poverty Run marine limestone: Ohio – Marple, 1951.
Queenslie Marine Band: Scotland – Manson, *1957.
Silvester's Marine Band: England – Mitchell, Stubblefield, and Crookall, *1945.
Skipsey's Marine Band: Scotland – Currie, Duncan, and Muir-Wood, *1937, Rhodes, 1953*b*.
Smithwick group: Texas – Levinson, 1953.
Stanley shale: Arkansas – Hass, 1950; Oklahoma – Hass, 1950.
Stinking Marine Band: England – Mitchell, Stubblefield, and Crookall, *1945; Stubblefield and Calver, *1955.
Tonge's Marine Band: England – Earp and Magraw, *1955; Magraw, *1957.
Upper Band Coal: England – Eden, *1954.
Upper Mercer marine limestone: Ohio – Marple, 1951.
Unnamed formation: Colorado – Chronic, 1958; England – Woodland, and others, *1957.
West Hill Marine Band: England – Mitchell, Stubblefield, and Crookall, *1945.

MIDDLE PENNSYLVANIAN

Brereton cyclothem: Illinois – Wanless, 1957.
Excello formation: Kansas – Howe, 1956.
Gimlet cyclothem: Illinois – Wanless, *1958.
Hermosa formation – see Paradox member.
Liverpool cyclothem: Illinois – Wanless, 1957, *1958; Zangerl and Richardson, 1955.
Paradox member of the Hermosa formation: Paradox Basin – Herman and Barkell, 1957; Jones, D. J., 1958*a*.
Saint David cyclothem: Illinois – Wanless, 1957, *1958.
Saint David formation: Illinois – Rhodes, *1952.
Scammon formation: Kansas – Howe, 1956.
Seahorne cyclothem: Illinois – Wanless, *1958.
Seville cyclothem: Illinois – Wanless, *1958.

Sparville cyclothem: Illinois – Wanless, 1957, *1958.
Strawn series: Texas – Levinson, 1953.
Trivoli cyclothem: Illinois – Wanless, 1958.
Unnamed formation: Colorado – Chronic, 1957; Illinois – Rhodes, *1952; Indiana – Stainforth, 1956; Kentucky – Rhodes, *1952; Texas – Levinson, 1957.
Verdigris formation: Kansas – Howe, 1956.

UPPER PENNSYLVANIAN

Aarde shale member of the Howard formation: Kansas – McMillan, 1956.
Heebner shale member of the Oread limestone: Kansas – O'Connor, 1955; Wagner, 1954; Wagner and Harris, *1953.
Holt shale member of the Topeka limestone: Kansas – Moore, Frye, Jewett, and O'Connor, 1951.
Howard formation: Kansas – McMillan, 1956.
Lecompton limestone – see Queen Hill shale member.
Oread limestone – see Heebner shale member.
Queen Hill shale member of the Lecompton limestone: Kansas – Moore, Frye, Jewett, and O'Connor, 1951; O'Connor, 1955.
Robbins shale: Kansas – Miller and Swineford, *1957.
Topeka limestone – see Holt shale member.
Trivoli cyclothem: Illinois – Wanless, 1958.
Unnamed formation: Illinois – Rhodes, *1952; Iowa – Payton and Thomas, 1958; Nebraska – Payton and Thomas, 1958; Texas – Levinson, 1957.

LOWER PERMIAN

Bennett shale: Kansas – Youngquist, Hawley, and Miller, 1951.
Grenola limestone – see Neva limestone member.
Hughes Creek shale: Kansas – Youngquist, Hawley, and Miller, 1951.
Neva limestone member of the Grenola limestone: Kansas – Lane, 1958.
Speiser shale: Kansas – Hattin, 1957.
Unnamed formation: New Mexico – Thompson and Kottlowski, 1955.
Wreford limestone: Kansas – Hattin, 1957.

MIDDLE PERMIAN

Phosphoria formation: Idaho – Youngquist, Hawley, and Miller, *1951.
Unnamed formation: Sicily – Müller, *1956*a*.
Zechstein 1: Germany – Malzahn, *1957.

UPPER PERMIAN

Zechsteinkonglomerat (Devonian conodonts were found in pebbles in this unit): Germany – Teichmüller and Ziegler, *1957.

TRIASSIC (UNDIVIDED)

Unnamed formation: Palestine – Youngquist, 1952.

LOWER TRIASSIC

Celtites bed: West Pakistan – Huckriede, *1958.
Rhynchonellenbank: West Pakistan – Huckriede, *1958.
Seiser Schichten: Austria – Huckriede, *1958.
Thaynes formation: Idaho – Müller, 1956*a*; Youngquist, 1952.
Unnamed formation:
Nevada – Clark, D. L., *1957; Müller, 1956*a*; Utah – Clark, D. L., *1957; West Pakistan – Huckriede, *1958, Schindewolf, *1954*a*.
Untere Ceratitenschichten: West Pakistan – Huckriede, *1958.

MIDDLE TRIASSIC

Buchensteiner Schichten: Austria – Huckriede, *1958.
Bulogkalk: Bosnia – Huckriede, *1958; Greece – Huckriede, *1958.
Cephalopodenkalk: Bosnia – Huckriede, *1955.
Gebel Araif el Naga: Egypt – Müller, 1956*a*.
Hornsteinkalk: Austria – Huckriede, *1955.
Hornsteinknauerkalk: Austria – Huckriede, *1958.
Lesestein: Austria – Pilger and Schönenberg, 1958.
Muschelkalk: Germany – Diebel, 1956*a*, Kockel and Tatge, *1955, Tatge, *1956.
Pietra verde-Niveau: Italy – Pilger and Schönenberg, *1958.
Pit shale: Nevada – Müller, 1956*a*.
Ramsaudolomit: Austria – Huckriede, *1958.
Schreyeralmkalk: Austria – Huckriede, *1955, *1958.
Schusterbergkalk: Austria – Huckriede, *1955, *1958; Pilger and Schönenberg, 1958.
Steinalmkalk: Austria – Huckriede, *1958.
Trinodosus stufe: Austria – Pilger and Schönenberg, *1958; Greece – Huckriede, *1958; Turkey – Huckriede, *1958.
Trochitenkalk: Germany – Müller, 1956*a*.
Unnamed formation: Austria – Diebel, *1956*a*, Huckriede, *1955, *1958; Bosnia – Huckriede, *1958; Greece – Huckriede, *1958; Turkey – Huckriede, *1955.
Wettersteinkalk: Austria – Huckriede, *1958.
Zone of *Ceratites trinodosus:* Austria – Pilger and Schönenberg, 1958.

UPPER TRIASSIC

Fustapidimakalk: Corfu – Huckriede, *1958.
Hallstätter Kalk: Austria – Huckriede, *1955, *1958.
Hallstätter Riffkalk: Austria – Huckriede, *1958.
Pseudohallstätter Kalk: Austria – Huckriede, *1958.
Unnamed formation: Austria – Huckriede, *1958.

UPPER CRETACEOUS

Mungokreide: Cameroons – Diebel, *1956*b*, 1957, Fay, 1957; Huckriede, 1958.

DISTRIBUTION OF CONODONT-BEARING FORMATIONS

Knowledge of the geological and geographical distribution of conodonts has enlarged considerably since July 31, 1949. In that year conodonts were thought to range from Early Ordovician through Middle Triassic time and had been found in about 16 countries. As of December 31, 1958, the range of conodonts was known to be from Late Cambrian through Late Triassic time and possibly through Late Cretaceous time, and they were known to occur in about 31 countries (Table 1).

By referring to Table 1 and the geological indexes and accompanying bibliographies in the Catalogue of Conodonts and in this paper, published articles can be located which mention conodont-bearing formations of a certain geologic system in a particular geographical area.

TABLE 1

GEOLOGICAL AND GEOGRAPHICAL DISTRIBUTION OF CONODONT-BEARING FORMATIONS.

F, occurrence recorded in the Catalogue of Conodonts (Fay, 1952). A, occurrence recorded in this paper.

	CAMBRIAN	ORDO-VICIAN	SILURIAN	DEVONIAN	MISSISSIP-PIAN	PENNSYL-VANIAN	PERMIAN	TRIASSIC	JURASSIC	CRETACE-OUS
AFRICA										
Algeria			A	A	A					
Cameroons										A
Egypt					F, A	F, A		F, A		
ASIA										
West Pakistan								A		
AUSTRALIA										
Central		F, A								
Western		A	A	A	A					
EUROPE										
Austria				A	A			A		
Baltic region		F								
Belgium					F					
Bosnia								A		
Corfu								A		
Czechoslovakia		F	F							
Estonia		F, A	F							
France				A	A					
Germany	A	A	F, A	F, A	F, A	A	F, A	F, A		
Great Britain										
England		A	F, A	A	F, A	F, A				
N. Ireland					A	A				
Scotland		F, A			F, A	F, A				
Greece								A		
Italy				A				A		
Netherlands						A				
Ösel Island			F, A							
Palestine								A		
Poland				F						
Prussia			F							
Russia		F		F	F					
Sicily							A			
Silesia		F		A						
Spain			A	A	A					
Sweden		F, A								
Turkey				A				A		
NORTH AMERICA										
Canada										
Alberta				F, A	F					
Mackenzie region				F						
Ontario		F		F, A						
Quebec		F								
United States										
Alabama				F, A	A					

Bosnia								A		
Corfu								A		
Czechoslovakia		F	F							
Estonia		F, A	F							
France				A	A					
Germany	A	A	F, A	F, A	F, A	A	F, A	F, A		
Great Britain										
England		A	F, A	A	F, A	F, A				
N. Ireland					A	A				
Scotland		F, A			F, A	F, A				
Greece								A		
Italy				A				A		
Netherlands						A				
Ösel Island			F, A							
Palestine								A		
Poland				F						
Prussia			F							
Russia		F		F	F					
Sicily							A			
Silesia		F		A						

Russia		F		F	F						
Sicily							A				
Silesia		F		A							
Spain			A	A	A						
Sweden		F, A									
Turkey				A					A		
NORTH AMERICA											
Canada											
Alberta				F, A	F						
Mackenzie region				F							
Ontario		F		F, A							
Quebec		F									
United States											
Alabama		•		F, A	A						
Arizona				A							
Arkansas		•		F, A	F, A	A					
Cincinnati arch				A							
Colorado		F, A		A		F, A					
Idaho							A	A			
Illinois		A	A	F, A	F, A	F, A					
Indiana		A	F	F	F, A	F, A					
Iowa		F, A	F, A	F, A	F, A	F, A					
Kansas					F	F, A	F, A				
Kentucky		F, A	F	F	F, A	A					
Maryland				F							
Michigan		A		F, A	A						
Minnesota		F, A		F							
Mississippi				F, A	A						
Mississippi Valley		A		A	A						
Missouri		F, A	F, A	F, A	F, A	F					
Montana		A		F, A	F, A	F, A					
Nebraska						A	F				
Nevada		A		A				A			
New Jersey		A									
New Mexico				A		A	A				
New York		F		F, A							
North Dakota		F, A			F	F					
Ohio		F, A		F, A	F, A	F. A					
Oklahoma	A	F, A	F, A	F, A	F, A	F, A					
Pennsylvania		F, A		A							
Paradox basin						A					
South Dakota	A	F, A									
Tennessee		F, A		F, A	F, A						
Texas		F, A	F, A	F, A	F, A	F, A					
Utah	A					F		A			
Virginia				F							
Washington					A						
Wisconsin				F							
Wyoming	A	F, A		F, A	F	F	F				
SOUTH AMERICA											
Argentina		A									

TABLE 1

Arizona							

ISRAEL

Z. REISS

THE HEBREW UNIVERSITY

Several research projects involving the study of foraminifera, carried out under the guidance of Professor M. Avnimelech and your correspondent by University students toward their M. S. degrees, were completed. Some of these projects were partly financed by the Geological Survey of Israel, which also provided working facilities in its Paleontology Division.

A. Issar published a summary of his thesis, entitled "Remarks on the subsurface geology of the central foothills region of Israel" (Geol. Survey Israel, Bull. no. 23, 1959). This paper dealt with the structural evolution of the central foothills region as revealed by litho- and biofacies studies of Turonian to Neogene strata. The stratigraphy was based entirely on foraminifera, and the numerical composition of the foraminiferal assemblages in the various strata was used in addition to lithologic and mineralogical data in interpreting the depositional environment. The study demonstrated lateral facies changes connected with predepositional relief. The main folding of the SW—NE trending anticlines occurred in the late Turonian and early Senonian, causing unconformities in the Senonian-Tertiary sequence. Geologic sections illustrating the relationships between the various litho- and biofacies types accompany the paper.

U. Berner completed his M. S. thesis, on the "Subsurface geology of the eastern Coastal Plain of Israel." In this study he used foraminifera for determining the ages of Senonian-Maestrichtian and Tertiary strata.

B. Derin is preparing his thesis, on "Paleocene planktonic foraminifera from the Nitzana region (NW Negev)," for publication. The paper deals with the biostratigraphy of the Taqiya formation, of Paleocene age, based on rich planktonic foraminiferal faunas. The zonation agrees well with that established by means of planktonic foraminifera in other parts of the world, especially in the Western Hemisphere. Distribution and correlation charts, as well as figures of specimens examined, accompany the paper.

L. Mor-Garelik has completed her investigation of *Nummulites* in Paleocene limestones of the Nitzana region and is now preparing a summary of her thesis for publication. Her paper will contain photomicrographs and camera lucida drawings of isolated specimens and oriented thin-sections, as well as tables of data on the various species of *Nummulites* identified either definitely or provisionally. The *Nummulites* assemblage shows, in general, more affinities with those recorded from Europe (Switzerland and Poland) and certain parts of Asia (India) than with the assemblages recorded from Egypt. The occurrence of "pillared" species is of particular interest. The stratigraphic position of the *Nummulites*-bearing limestone intercalations can be established fairly exactly on the basis of the rich planktonic faunules contained in the over- and underlying Taqiya shales.

S. Greitzer and A. Golik have prepared summaries of their theses for publication. They deal with the stratigraphy and structure of the southern foothills region of Israel, based almost entirely on micropaleontological studies of surface and subsurface samples. Distribution charts of microfossils (mainly foraminifera) and geologic sections are included.

A. Eker is working at present on his thesis, on "Microfaunas and microfacies of early Turonian formations of Israel." The results obtained thus far to some extent differ from the opinions held by various geologists with regard to the age of certain lithostratigraphic units. They agree well, however, with those held by R. Freund, of the Hebrew University, on the basis of his study of Turonian ammonites.

GEOLOGICAL SURVEY OF ISRAEL

Several research projects initiated earlier are progressing steadily, and some have been finished. Early in 1960, your correspondent completed a micropaleontological study of Quaternary subsurface strata in the Tel Aviv region. This investigation was carried out in close cooperation with the G. S. I. Hydrogeology and Mineralogy Divisions, as well as with TAHAL (Water Planning for Israel, Ltd.). A. Issar, of the G. S. I. Hydrogeology Division, was responsible for the lithologic and general geological parts of the investigation. Microfaunas from about 1400 samples from 25 water wells were analyzed in order to establish the stratigraphic and paleoecologic significance of the genera and species present, as well as the

numerical composition by bionomic groups of the foraminiferal assemblages. Six marine complexes were recognized in the western part of the Tel Aviv region, of Calabrian, Sicilian, Tyrrhenian (s. l.) (two ingressions), and "post-Tyrrhenian" age. Each of these complexes is characterized by a distinct foraminiferal assemblage reflecting the environmental conditions. Each was deposited in shallower waters than the subjacent one. Toward the East, each complex interfingers with shallower-water and terrestrial deposits. The foraminiferal assemblages characteristic of younger complexes in the West occur in stratigraphically older complexes in the East. Some of the genera and species of foraminifera seem to reflect climatic conditions rather than local environment of deposition. The ratio between Quaternary foraminifera and redeposited pre-Quaternary forms correlates well with the percentage curves for *Ammonia* and with those for certain heavy minerals, i.e., those of flaky form and of specific gravity not over 3.6. The correlation is explained by the influence of near-shore currents, carrying flooding Nile River water, on salinity and on mineral sorting by form and specific gravity. A comparison with present-day conditions on the continental shelf of Israel (to be published by K. O. Emery, Y. Bentor, and D. Neev in the G. S. I. Bulletin) has made it possible to interpret the depositional environment of the Quaternary strata. This interpretation is also based partly on a study of Recent microfaunas from the Mediterranean and Red Sea. The results of this investigation will be published shortly in the G. S. I. Bulletin (A. Issar and Z. Reiss: "Subsurface Quaternary correlations in the coastal plain of Israel," and Z. Reiss, K. Klug, and P. Merling: "Recent foraminifera from the Mediterranean and Red Sea"). Well logs, distribution charts, and percentage curves of microfossils and minerals accompany these papers.

The investigation of the subsurface Lower Cretaceous of the southern coastal plain, in collaboration with the Oil Division of the G. S. I., has continued and two papers were published, dealing mainly with stratigraphic data: P. Grader: "Geological history of the Heletz-Brur area, Israel; Part 1-Upper Cretaceous-Quaternary" (Geol. Survey Israel, Bull. no. 22, 1958); and P. Grader, Z. Reiss, and K. Klug: "Correlation of subsurface Lower Cretaceous units in the southern coastal plain" (ibid. no. 28, 1960). These papers contain faunal lists, distribution charts, and correlation tables. Mrs. K. Klug and your correspondent are now preparing a paper dealing with the taxonomic problems of the early Cretaceous foraminifera recorded to date.

In collaboration with Mrs. P. Merling, your correspondent has continued the intensive study of subsurface formations of Oligocene and Neogene age in the coastal plain of Israel. This investigation is being carried out in cooperation with the G. S. I. Oil Division, Sedimentological Laboratory, and Geochemistry Division (Analytical Laboratory and X-Ray Section). An attempt is being made to correlate numerical data obtained by counting microfossils (mainly foraminifera) from a large number of core samples with heavy-mineral, granulometric, and X-ray data. The strata are being zoned in great detail by means of planktonic foraminifera. The first results obtained seem to be rather significant, and have contributed much to a better understanding of the geologic history of the coastal plain during Oligocene and Miocene time, especially by providing reliable data for the stratigraphic correlation of wells.

Taxonomic studies of various groups of foraminifera have continued in the G. S. I. Micropaleontological Laboratory. Your correspondent published a short paper, "The wall-structure of *Cibicides*, *Planulina*, *Gyroidinoides*, and *Globorotalites*" (Micropaleontology, vol. 5, no. 3, 1959), and another entitled "Note sur *Pseudolituonella*" (Rev. Micropal. vol. 2, no. 2, 1959). In collaboration with Mrs. P. Merling, he also published a paper entitled "Structure of some Rotaliidea" (Geol. Survey Israel, Bull. no. 21, 1958), in which the structural features of *Rotalia*, *Ammonia*, *Asterorotalia*, *Pararotalia*, *Calcarina*, *Cuvillierina*, *Notorotalia*, and the Rotaliidea (s. str.) in general were discussed. A new genus, *Pseudorotalia* (type species: *Rotalia schroeteriana* Parker and Jones), was established. A paper on the "Structure of so-called Eponides and some other 'rotaliiform' foraminifera" has been prepared by your correspondent and will be published shortly in the G. S. I. Bulletin. The structural features and the morphological and apertural characters of *Poroeponides*, *Alabamina*, *Osangularia*, *Cribroparrella*, *Conorotalites*, *Globorotalites*, *Gyroidinoides*, *Rotalia*, and *Nezzazata* are discussed and compared. *Eponides* is regarded as a *nomen dubium* and suppressed, and two new genera are established. It is shown that *Poroeponides* is completely unrelated to *Alabamina*, as believed by some authors, but, on the other hand, that such species as "*Eponides*" *beisseli*, *frankei*, *umbonata*, etc. differ in their characters from *Alabamina* only in degree and not in kind. A feature of taxonomic significance, the "murus reflectus," is described in several genera. The apertural characters of *Osangularia* and *Cribroparrella* are reinterpreted, and the "tectum," "scrobis septalis," and "infundibulum" of various genera are discussed. The study shows that many genera of foraminifera have been incompletely or erroneously described. Photomicrographs and camera lucida drawings illustrate the features discussed and especially the wall structure of the various genera mentioned.

Microfossils identified by your correspondent were listed by A. Shadmon in a description of the type section of the Bi'na limestone, of Cenomanian to Turonian age (Geol. Survey Israel, Bull. no. 24, 1959), and by M. Avnimelech in a paper entitled "Sur la présence de *Carcharodon angustidens* Agassiz dans l'Éocene moyen méditerranèen" (C. R. Somm. Soc. Géol. France, no. 2, 1959).

A large amount of routine work was carried out by the G.S.I. Micropaleontological Laboratory during the past two years in connection with geologic mapping and exploration activities pertaining to oil, groundwater, and mineral resources, both for the G.S.I. Divisions and for various companies operating in the country. Your correspondent also took an active part in the preparation of the fascicule "Israel" of the International Stratigraphic Lexicon. From September through December 1959, he served as a United Nations Technical Assistance Operations expert in Turkey, where he organized the micropaleontological laboratory of the Turkish Petroleum Corporation in Batman. While in Turkey he had the pleasure of meeting Mme. M. Tasman, Dr. Suat Erk, and C. Morris, as well as Dr. L. Dubertret, with whom he discussed various problems of micropaleontology and stratigraphy.

Visitors to the G.S.I. Paleontology Division during the past two years include Professor K. O. Emery (on sabbatical leave from the University of Southern California), Dr. C. Teichert, of the U. S. Geological Survey, Denver (on a personal visit), and Professor R. F. Rutsch, of the University of Bern, at present acting as a UNTAO expert in megapaleontology and concerned with the reorganization of the Megapaleontological Laboratory. I. Kafescioglu, micropaleontologist with the Turkish Petroleum Corporation, is at present studying at the G.S.I. Micropaleontological Laboratory on asix-month fellowship.

Z. Reiss
Paleontology Division
Geological Survey of Israel
Jerusalem, Israel

PORTUGAL—OVERSEAS

ARMENIO TAVARES ROCHA

SÃO TOMÉ AND PRÍNCIPE ISLANDS

G. Henriques da Silva published a paper entitled "Contribuição para o conhecimento da microfauna do Miocénico marinho da ilha do Príncipe" in Garcia de Orta (review of the Junta de Investigações do Ultramar) (vol. 6, no. 3, pp. 507–510, Lisbon, 1958). He reported abundant but poorly preserved foraminifera of the genera *Amphistegina* (probably *A. lessonii* d'Orbigny), *Textularia*, *Globigerina* (*G.* sp. aff. *G. triloculars* d'Orbigny), and others, as well as limestones with *Lithothamnium*.

Manuel Assunção Diniz presented the results of a microfaunal study of various samples collected from the littoral sands of São Tomé and Principe and the small island of Rolas. His paper, entitled "Contribuição para o conhecimento dos foraminíferos do arquipélago de S. Tomé e Príncipe," was published in Garcia de Orta (vol. 7, no. 3, pp. 453–470, 1959). Foraminifera are predominant in these littoral sands, but ostracodes, echinoderms, etc. are also recorded. The paper includes lists of fossils by samples and by specimens.

ANGOLA

In 1957, Professor Miguel Montenegro de Andrade and Dr. Joaquina Borges Montenegro de Andrade published a paper entitled "Estado actual dos conhecimentos sobre a paleontologia de Angola" in "Estudos de Geologia e Paleontologia" (Anais da Junta de Investigações do Ultramar, vol. 12, no. 4, pp. 1–209). It represents a major bibliographic study of papers published on the fossils of Angola up to the end of 1955. Lists of microfossil species identified to that date are given.

Maria de Lourdes Ubaldo and Maria Helena V. da Cunha presented a paper entitled "Petrografia de alguns calcários de Catumbela," published in Garcia de Orta (vol. 7, no. 4, pp. 791–797, 1959). They record foraminifera (Textulariidae, Globigerinidae, Rotaliidae, and Miliolidae) from an oolitic calcarenite. In addition, they identified foraminifera, mollusk fragments, echinoderms, and parts of calcareous algae of the genera *Lithothamnium* and *Amphiroa* from a calcareous sandstone.

The same authors also published a paper entitled "Notas petrográficas sobre os calcários da região de Catumbela-Bocoio" in Garcia de Orta (vol. 6, no. 3, pp. 511–520, 1958), on some calcarenites from the Cretaceous of Angola. They are principally oolitic, some containing abundant fossils. The foraminifera represented belong to the Textulariidae and Globigerinidae. In some calcarenitic sandstones, abundant fragments of calcareous algae of the genus *Lithothamnium* were found.

TIMOR

Robert Gageonnet and Marcel Lemoine published a paper entitled "Note préliminaire sur la géologie du Timor portugais" in Garcia de Orta (vol. 5, no. 1, pp. 153–163, 1957). Another paper by the same authors, "Contribution à la connaissance de la géologie de la province portugaise de Timor," appeared in "Estudos, Ensaios e Documentos" (no. 4, published by the Junta de Investigações do Ultramar, pp. 1–136, Lisbon, 1958). In these papers, the authors refer to limestones with Radiolaria, Bryozoa, *Globotruncana*, *Discocyclina*, *Nummulites*, *Alveolina*, *Lepidocyclina*, etc., determined by J Sigal.

Armenio Tavares Rocha
Algueirão, Portugal

RAYMOND C. DOUGLASS

U. S. NATIONAL MUSEUM

Richard Cifelli spent a part of last summer with Ralph Imlay and Norman Sohl of the U. S. Geological Survey, collecting key sections of Jurassic rocks in South Dakota, Montana, and Wyoming. This is part of a project to describe the Jurassic foraminifera of the western interior. The material is now being prepared for study.

In August, and again in October, Cifelli collected pelagic foraminifera in plankton tows from 200 meters of water along a series of stations extending from Montauk Point into the Sargasso Sea. Tows were made from the Woods Hole research vessel, *Crawford*. Future tows are planned along the same traverse in a program to study the distribution and temporal variation of pelagic foraminifera in the North Atlantic.

A study of the structure and morphology of topotypes of *Streblus beccarii* (Linné) is nearly completed. An abstract was presented for the G.S.A. meetings in Denver.

Richard Boardman is now Associate Curator in charge of invertebrate paleontology and paleobotany for the National Museum. His paper on trepostomatous Bryozoa of the Hamilton Group of New York State (U. S. Geol. Survey Prof. Paper 340), released in August, 1960, is an example of the application of detailed morphologic studies to the understanding of ontogeny and phylogeny in bryozoans. Another paper by Boardman, on a revision of the Silurian bryozoan genus *Trematopora*, published in the Smithsonian Miscellaneous Collections series, presents a detailed study of the genus, illustrated with excellent photomicrographs. He also has a paper in press on a revision of the Ordovician bryozoan genera *Batostoma*, *Anaphragma*, and *Amplexopora*, to appear in the Smithsonian Miscellaneous Collections series.

Visitors to the National Museum collections of foraminifera included Dr. K. A. Andersen of Louisiana State University; James Jones of the University of Wisconsin; Dr. Kenneth Hooper of Carleton University, Ottawa, Canada; Mrs. Esther Applin of the U. S. Geological Survey, Mississippi; Dr. Martin Glaessner; and Dr. Willet of New Zealand.

U. S. GEOLOGICAL SURVEY

Ruth Todd received a citation from the Society of Economic Paleontologists and Mineralogists for the best paper of 1959 for her paper, with Paul Blackmon, entitled "Mineralogy of some foraminifera as related to their classification and ecology," published in the January, 1959 number of the Journal of Paleontology. Papers published in 1960 include: "Conflicting age determinations suggested by foraminifera on Yap, Caroline Islands" (with W. S. Cole and C. G. Johnson) (Bull. Amer. Pal., vol. 41, no. 186, pp. 77–112, pls. 11–13, text-fig. 1, tables 1–3); "Some observations on the distribution of *Calcarina* and *Baculogypsina* in the Pacific," (Tohoku Univ., Sci. Repts., ser. 2 (Geol.), Spec. vol. 4 (Shoshiro Hanzawa Mem. Vol.), pp. 100–108, pl. 10, text-fig. 1, tables 1–2); and "Smaller foraminifera from Eniwetok drill holes" (with Doris Low) (U. S. Geol. Survey, Prof. Paper 260–X, pp. 799–861, pls. 255–264, text-figs. 256–259, tables 1–7).

Papers in press or nearly completed are: "Foraminifera from Onotoa Atoll, Gilbert Islands" (U. S. Geol. Survey Prof. Paper); "Near-shore foraminifera of Martha's Vineyard Island, Mass." (with Doris Low) (Cushman Found. Foram. Res., Contr., vol. 12, pt. 1, 1961); and "Upper Cretaceous foraminifera from wells along the south shore of Long Island" (with N. M. Perlmutter). Papers in progress include: "Recent and Tertiary smaller foraminifera of Guam, Mariana Islands"; "Globigerinid assemblages from deep-sea cores off the Marshall Islands"; "Ecologic study of foraminifera from the Bahama Banks and Florida Straits" (with Doris Low); and "Recent foraminifera from Pamplona searidge in Gulf of Alaska" (with Doris Low).

Miss Todd has recently been studying deep-sea fossil foraminifera from a 10-meter core taken in the South Atlantic off southwestern Africa, in which the lower third (290 cm.) of the core is virtually a Cretaceous deep-sea ooze, indicating Maestrichtian age. She has also been investigating other deep-sea foraminifera from some dredge samples of calcareous sand from the tops of two eastern Atlantic seamounts, where a mixture of Miocene and Recent Foraminifera was found.

I. G. Sohn reports that his "Lower Tertiary ostracodes from Pakistan, with a section on the preparation and study of Ostracoda" was approved for publication by the Director of the U. S. Geological Survey. This paper will be published by the Geological Survey of Pakistan. He is continuing his studies of Late Paleozoic ostracodes, Lower Cretaceous ostracodes from the Black Hills of South Dakota and Wyoming, and Lower Cretaceous ostracodes from Israel. William Briggs, Jr., is preparing a Masters dissertation on Late Tertiary ostracodes from Palau under his supervision.

Jean Berdan is currently working on Upper Silurian and Lower Devonian ostracodes of Maine. She reports the following recent publications: "Revision of the ostracode family Beecherellidae and redescription of Ulrich's types of *Beecherella*" (Jour. Pal., vol. 34, no. 3, pp. 467–468, pl. 66, 1960); and "The ostracode family Berounellidae, new"

(with I. G. Sohn) (Jour. Pal., vol. 34, no. 3, pp. 479–482, pl. 67, 1960).

Lloyd Henbest presented a paper at the A.A.P.G. meeting in Atlantic City on reclassification, living habits, and shell mineralogy of certain Late Paleozoic sedentary foraminifera. He has a paper in progress on their biology, shell structure, and parasites.

Your correspondent presented a paper on Pennsylvanian and Permian fusulinid foraminifera of northeastern Nevada at the G.S.A. meetings in Denver. He is continuing extensive studies of fusulinid taxonomy and distribution in the Basin Ranges. Two of his papers on Orbitolinidae appeared during 1960, one as Professional Paper 333, on *Orbitolina* in North America, and the other on the family Orbitolinidae, in this journal. A note on some Orbitolinas from Caribbean islands is in press in the Journal of Paleontology.

McLEAN PALEONTOLOGICAL LABORATORY

Joseph Sabol, an associate of the McLean Paleontological Laboratory, has an article in press entitled "Microfauna of the Yorktown Formation from James River, Surrey County, Virginia" (Bull. Amer. Pal., vol. 41, no. 191). The ranges of the faunas described by McLean in a previous bulletin of the same series are extended laterally.

The laboratory is beginning an extensive revision of "*Later Tertiary foraminiferal zones of the Gulf Coast*," its first publication. They hope to extend the zones through the Cretaceous of the Gulf region and to bring the Miocene-Oligocene zones up to date from 1945. It is hoped that at least 150 pages of this compilation will be issued during 1961, and that regular supplementary units will be added thereafter.

The second supplement to the "Manual of micropaleontological techniques" will also be published some time in 1961.

The laboratory is also interested in a card catalogue of foraminiferal ecology and would like to hear from others about their views and whatever work may be in progress in this area of study. The H. S. Puri Card Catalogue of Recent Ostracoda was started in 1960 in an effort to begin collecting ecological data in order to make it available in usable form.

YALE UNIVERSITY

Charles A. Ross has left Yale to join the staff of the State Geological Survey of Illinois. His paper on fusulinids from the Hess member of the Leonard formation in the Glass Mountains, Texas, was published in the October issue of the Contributions from the Cushman Foundation for Foraminiferal Research and was presented orally at the G.S.A. meetings in Denver.

C. O. Dunbar and C. A. Ross have prepared a paper on fusulinids from Greenland. Don Eicher's paper on the stratigraphy and micropaleontology of the Thermopolis shale was published as Bulletin 15 of the Peabody Museum of Natural History. It includes descriptions of arenaceous foraminifera and some Radiolaria.

Thomas Williams is completing his doctoral dissertation on the stratigraphy and fusulinids of the type Hueco limestone in Texas. James F. Melo is engaged in a study of microfossils in the Mobridge and Elk Butte members of the Pierre and in the overlying Fox Hills formation in the type areas of these units.

CORNELL UNIVERSITY

K. Norman Sachs, Jr., completed his doctorate in June and accepted a position with the University of Florida. His dissertation was a revision of the American Lepidocyclinas. Barnum K. Sen Gupta is finishing a Master's thesis on some Indian larger foraminifera.

W. Storrs Cole has a Professional Paper in press on the discovery of Eocene and Oligocene foraminifera on Fiji. In addition to his paper on *Lepidocyclina* in the April, 1960, issue of Micropaleontology, he published the following papers in 1960: "Conflicting age determinations suggested by foraminifera on Yap, Caroline Islands" (with Ruth Todd and C. G. Johnson) (Bull. Amer. Pal., vol. 41, no. 186, pls. 11–12); "Problems of the geographic and stratigraphic distribution of certain Tertiary larger foraminifera" (Tohoku Univ., Sci. Rept., ser. 2 (Geol.), Spec. vol. 4 (Shoshiro Hanzawa Mem. Vol.), pp. 9–18); "Revision of *Helicostegina*, *Helicolepidina*, and *Lepidocyclina* (*Polylepidina*)" (Contr. Cushman Found. Foram. Res., vol. 11, pl. 2, pp. 57–63, pls. 10–13); and "The genus *Camerina*" (Bull. Amer. Pal., vol. 41, no. 190, pp. 189–205, pls. 23–26).

AMERICAN MUSEUM OF NATURAL HISTORY

Miss Angelina R. Messina attended the twenty-first International Geological Congress in Copenhagen. After the completion of the sessions and field trips, she visited micropaleontological laboratories in Moscow, Leningrad, Vienna, Warsaw, Rome and Madrid. Miss Carol Turco also attended the sessions after touring several countries in Europe.

The Department of Micropaleontology received a grant-in-aid from the National Science Foundation early in 1960 to conduct basic research on the biology of foraminifera. Under the supervision of Dr. John Lee, and with the aid of Stanley Pierce and Mrs. Marilyn Tentchoff, a microbiological laboratory was established and a study of the physiology of the foraminifera was undertaken. Much of the summer was spent in collecting foraminifera from the waters around New York, New Jersey and Long Island. These collections, and some foraminifera collected in Bermuda by Dr. Allan Bé and Norman Block, comprise littoral and pelagic foraminifera which have been cultured in the laboratory. So far, successful cultures have been made axenically (free of any other organism), synxenically (with known cultural associates) and agnotobiotically (with unidentified organisms) with specimens of *Anomalina*, *Allogromia*, *Archaias*, *Ammodiscus*, *Amphistegina*, *Cor-*

nuspira, *Elphidium*, *Globigerina*, *Globorotalia*, *Lenticulina*, *Miliammina*, *Nonion*, *Nonionella*, *Patellina*, *Peneroplis*, *Planulina*, *Quinqueloculina*, *Streblus*, *Triloculina* and *Trochammina*. Various types of media, enrichments, and naturally associated fauna and flora are being screened for their ability to support the growth and reproduction of these foraminifera. Preliminary reports of this work have been published in the Journal of Protozoology. Among a number of interesting nutritional factors already uncovered in exploratory experiments is a foraminiferal response to certain algae which stimulate the formation of pseudopods and a nutrilite which causes a type of budding to take place in *Streblus beccarii*.

Although the study of life cycles is not of primary interest in this project, Mrs. Tentchoff is studying the natural life cycles occurring in the populations of arenaceous foraminifera found at Cold Spring Harbor, L. I. and Dr. Hugo Freudenthal and Jan Prager have been studying the morphology and life cycles of local dinoflagellates.

During 1960, the following micropaleontologists were among the numerous visitors to the Department: Ted Bourgeois, William R. Evitt, Martin F. Glaessner, Darwin O. Hemer, David D. Hughes, Stuart A. Levinson, B. Sen Gupta, I. G. Sohn, Joseph T. Sperrazza, and John A. Sulek.

NEW YORK UNIVERSITY

Brooks F. Ellis and A. W. McCrone of the Department of Geology are continuing their studies of marine lithofacies and biofacies in Long Island Sound. The coring program was completed in October, 1960, but the laboratory studies are expected to continue through 1961.

In August, Edwin K. Hoiles completed his Master's thesis on "Smaller index foraminifera in random thin section." In September, William Molitor completed his radioactivity survey of selected sediments from western Long Island Sound.

Richard Charmatz and Straton Podaras are continuing their Master's studies on foraminifera and spores, respectively, from Long Island Sound.

PRINCETON UNIVERSITY

W. Berggren, of the Geologiska Institutet, University of Stockholm, is spending the academic year 1960–61 in the United States, based at Princeton. He has in press a paper entitled "Paleogene biostratigraphy and planktonic foraminifera of the southwestern Soviet Union, an analysis of recent Soviet investigations," which will appear as Vol. 4, no. 6, of the Stockholm Contributions in Geology. He is completing a paper on the planktonic foraminifera of the Maestrichtian and Danian of Denmark and southern Sweden. During his sojourn in the United States he is especially interested in studying types, collecting topotype material, and communicating with fellow workers.

R. G. Osgood and A. G. Fischer published on "Structure and preservation of *Mastopora pyriformis*, an Ordovician dasycladacean alga" (Jour. Pal., vol. 34, pp. 896–902). Fischer is continuing his investigations of Triassic reef-dwelling foraminifera and problematica from the Northern Calcareous Alps.

Thomas Gibson is engaged in studies of the Miocene of the Atlantic Coastal Plain. They will deal chiefly with certain gastropods, but will also extend to Foraminifera.

PENNSYLVANIA STATE UNIVERSITY
PALYNOLOGICAL LABORATORIES

The staff, in addition to publishing the "Catalog of fossil spores and pollen," is programming a supplement of English translations to accompany this compendium. Taxa originally described in Russian and other unfamiliar languages, which appeared in Volumes 1–12 of the Catalog, are to be included in the early issues of these translations. Other activities of the laboratory include participation in an Organic Sediment Studies program and an intensive effort to expand the modern pollen reference collection. Prepared slides of some 1000 extant species are now available for exchange on a slide-for-slide basis.

Individual research programs include a detailed study of Pennsylvanian spore assemblages of the Brookville seam in the vicinity of Brookville, Pennsylvania, by Norman Frederiksen, who will shortly become associated with the Socony Mobil Oil Company. Gilbert J. Brenner is investigating a rich flora recovered from the Potomac group (Lower Cretaceous) sediments of Delaware, Maryland, and Virginia. Fossil spore and pollen assemblages of Middle Eocene formations from Amador and Contra Costa Counties, California, are being studied by Walter Riegel, an exchange student from Germany doing research in this country. Other palynological investigations of Eocene floras include those of H. Tate Ames, on Wilcox sediments from selected localities in Alabama, Mississippi, and Louisiana. The newest member of the laboratory, Ronald W. Stingelin, is investigating Quaternary bog deposits of northern Pennsylvania and New York State.

UNIVERSITY OF NORTH CAROLINA

Charles W. Copeland has completed the identification, description, and illustration of foraminiferal faunas from two localities in Duplin County North Carolina, and hopes to have the paper ready to submit for publication shortly. He has described just over 100 species from the Upper Miocene Duplin marl and the Upper Eocene Castle Hayne formation.

During the past year, Marcus B. Morehead made several extensive collections of Recent foraminifera from the Neuse River estuary and southern Pamlico Sound, North Carolina, as well as from bottom samples in open marine environments off the North Carolina coast. A number of remarkable chitinoid and arenaceous groups were found in low-salinity environments. Repeated collections are being made in order to determine seasonal variations in populations. Percentages of living and non-living specimens are noted, as well as the relationships of population composi-

tion to known physical, chemical, and biological environmental conditions.

Bobby Cahoon, a former undergraduate N.S.F. scholar now doing graduate work at the University of Wisconsin, completed a project on Upper Silurian Keyser stromatoporoids from a reef at Irongate, Virginia. In connection with the project, a paper-chromatography study of some stromatoporoid coenostea was made. Mr. Cahoon obtained a positive ninhydrin test for amino acid in several of the specimens tested and was able to identify glutamic acid in at least one specimen.

John Warren has come to the Department from Cornell University as a graduate assistant to Joseph St. Jean. He plans to undertake a study of Silurian or Lower Devonian stromatoporoid faunas in New York State for a Master's thesis.

Joseph St. Jean spent two weeks studying the Nicholson stromatoporoid collections in the British Museum of Natural History, London. He presented a paper on "The widespread distribution of characteristic Devonian stromatoporoid microstructures and their stratigraphic significance" at the International Geological Congress in Copenhagen, and made collections from all of the Silurian stromatoporoid-bearing formations on the island of Gotland, as well as from the Ordovician and Silurian of several localities near Oslo, Norway. A paper on the "Micromorphology of the stromatoporoid genus *Stictostroma* Parks" has been completed and submitted to the Journal of Paleontology for publication. Work continues also on the Middle Devonian stromatoporoid faunas of southern Ontario. The work will be extended into New York State, beginning next summer. A lower Miocene age was determined for a South African foraminiferal fauna from Umkwelane Hill, collected by J. J. Frankel of the University of Natal.

RAYMOND C. DOUGLASS
U. S. Geological Survey
Washington 25, D.C.

UNITED STATES—MID-CONTINENT REGION

DOROTHY J. ECHOLS

OKLAHOMA UNIVERSITY AND OKLAHOMA GEOLOGICAL SURVEY, NORMAN

Dr. Carl Branson, Director, and Dr. L. R. Wilson jointly prepared the following summary of micropaleontological activity. Since the 1958 report, numerous publications have appeared, and an active research program is continuing.

Thomas W. Amsden has recovered a conodont fauna from the Chimneyhill formation. M. K. Elias is studying the Atoka formation, and D. R. Waddell is examining the fusulinid collections. R. W. Harris is searching for specimens of *Hedbergia*, a monotypic genus, which is of Cretaceous age although originally considered Pennsylvanian. He is preparing a paper on Oil Creek conodonts and on a species of ostracode from the basal Tyler and topmost Burgen sandstone of northeastern Oklahoma. Anna Mae Killian is studying the ostracodes of the Haragan marlstone, B. E. Morgan is studying the foraminifera of the Pecan Gap in northeastern Texas, R. W. Harris, Jr., is studying the ostracodes of the McLish limestone, and J. E. Dempsey is completing his thesis on the index foraminifera of the Gulf Coastal Plain. These studies are under the direction of Dr. Harris.

D. B. Kitts has collected a large number of seeds from several levels in the Ogalla formation of Oklahoma. R. O. Fay is continuing to scan conodont literature to keep his catalog up to date. L. R. Wilson is expanding his studies on the palynology of the Flowerpot shale (Permian), and is studying the paleoecology of an Oklahoma ten-foot coal and, with Phillip Marsh, the microflora of the Lytle member of the Dakota sandstone. He is also directing and working with L. B. Gibson on the spores of the Iron Post coal (Pennsylvanian), with R. T. Clark on the spores of the Secor coal (Pennsylvanian), with M. J. Higgins on the spores of the "Porter" coal (Pennsylvanian), with V. D. Wiggins on the palynology of the Goddard shale (Mississippian), with P. N. Davis on the spores of the Rowe coal (Pennsylvanian), with E. L. Jones on the palynology of the Wilcox formation (Eocene), with E. J. Tynan on a hystrichospherid catalog, with J. B. Urban on the palynology of the Woodford shale (Devonian), and with R. W. Hedlund on the palynology of the Sylvan shale (Ordovician).

M. K. Elias has translated a paper published in Russian in 1953 by S. R. Samoilovich, on pollen and spores from the Permian of the Cherdynsk and Aktyubinsk areas. The translation will soon be published by the Oklahoma Geological Survey.

The following papers were published in 1959 (unless otherwise noted). C. C. Branson reported on a palynological meeting in Oklahoma (Okla. Geol. Notes, vol. 19, p. 42), and published a note entitled "A stratigraphic leak" (Okla. Geol. Notes, vol. 19, pp. 138–139). M. K. Elias published on the fusulinid genera *Protriticites*, *Pseudotriticites*, and *Putrella* (Okla. Geol. Notes, vol. 19, pp. 165–178) and on some Mississippian conodonts from the Ouachita Mountains (Dallas Geol. Soc. and Ardmore Geol. Soc., pp. 141–165). E. J. Tynan reported on an occurrence of *Cordaites michiganensis* in Oklahoma (Okla. Geol. Notes, vol. 19, pp. 43–46) and published a paper on the examination of pre-Simpson Paleozoic rocks for insoluble fossils (Univ. Texas, Publ. no. 5924, pp.

87–93). He has a paper on the archaeomonads of the Calvert formation of Maryland in press (Micropaleontology). L. R. Wilson had the following communications in the Oklahoma Geology Notes (vol. 19): "Geologic History of the Gnetales" (pp. 35–40); "Genotype of *Densosportites* Berry, 1937" (pp. 47–50); "A method of determining a useful microfossil assemblage for correlation" (pp. 91–93); "A water-miscible mountant for palynology" (pp. 110–111); and "Color transparencies of microfossil species types and typical specimens" (p. 114). He also published a paper on "The use of fossil spores in the resolution of Mississippian stratigraphic problems" (Tulsa Geol. Soc., Digest, vol. 27, pp. 166–171). In 1960, he published on "*Florinites pellucidus* and *Endosporites ornatus*, with observations on their morphology" (Okla. Geol. Notes, vol. 20, pp. 29–33) and on "Cover fossils" (Okla. Geol. Notes, vol. 20, pp. 1–2).

Dr. R. W. Harris contributed the following information: Master's theses recently completed at Oklahoma University were those of I. S. Gold, on "Marlbrook foraminifera of southwestern Arkansas," which includes 15 plates of foraminifera; Jean D. Mohn, on "La Luna (Upper Cretaceous) foraminifera from the State of Trujillo, Venezuela," in which approximately 48 species of foraminifera are described and illustrated; C. O. Matesich, on "Saratoga foraminifera from the type locality in southwestern Arkansas," illustrated with 16 plates of foraminifera; and C. L. Ramay, on "Clarification of Desmoinesian stratigraphy in the Pleasant Hill syncline of the Criner Hills, Oklahoma," in which *Fusulina eximia* Thompson, thirteen ostracodes, and two foraminifera from the Camp Ground member of the Deese formation are described. A Ph. D. thesis by C. L. McNulty, "Austin foraminifera from northeastern Texas," includes 10 plates of foraminifera. Dr. Harris is now working on a publication involving ostracodes and conodonts from the Simpson of northeastern Oklahoma.

JERSEY PRODUCTION RESEARCH COMPANY, TULSA

Dr. W. S. Hoffmeister reports that Dr. William R. Evitt spent two months in Europe studying dinoflagellates, coccoliths, and hystrichospherids under the direction of Dr. Alfred Eisenack in Germany and Dr. G. Deflandre in France. Dr. Jack Burgess, of the Humble Oil Company, Carter Division, was at the Research Center for four months undergoing training in palynology prior to setting up a laboratory in Billings, Montana. Drs. W. R. Evitt, J. W. Funkhouser, and W. S. Hoffmeister attended the Ninth International Botanical Congress in Montreal. Dr. Funkhouser was appointed a member of the International Committee for Paleobotanical Nomenclature and the International Committee on Neotypes. Dr. Evitt gave a paper on "Middle Silurian vascular plants from New York and Australia" at the Congress, and Dr. Funkhouser presented a paper on "A survey of non-spore-pollen palynology" at the same meeting.

Dr. Hoffmeister gave a paper entitled "A decade of palynology in oil exploration" as part of the invitation program on Stratigraphic and Ecologic Interpretation of Plant Microfossils in Petroleum Geology at the G.S.A. meeting in Pittsburgh. Dr. Hoffmeister recently returned from a visit to Intercol's palynological laboratory at Bogotá, Colombia.

PAN AMERICAN RESEARCH, TULSA

Dr. Charles F. Upshaw, formerly of the University of Missouri, has joined the staff of Pan American Research.

UNIVERSITY OF NEBRASKA, LINCOLN

Dr. J. A. Fagerstrom reports that all research in micropaleontology has come to a halt at Nebraska. The department will continue to offer one or two semesters of instruction every other year in micropaleontology, but since Dr. Fagerstrom's interest is in macro-invertebrates, no activity of any significance with micro-invertebrates is anticipated.

UNIVERSITY OF SOUTH DAKOTA, VERMILLION

Dr. Robert E. Stevenson, Chairman of the Department of Geology, reports that two M. A. theses in micropaleontology were completed in June, 1960, on "Microfossils of the Pierre formation Gregory facies" and "Microfossils of the Pierre formation Oacoma facies." Work on the microfossils of the Verendrye and Virgin Creek facies of the Pierre formation has been started.

SOUTH DAKOTA SCHOOL OF MINES AND TECHNOLOGY, RAPID CITY

Dr. Edward Tullis informs us that there is no news in the field of either micropaleontology or paleobotany.

UNIVERSITY OF NORTH DAKOTA, GRAND FORKS

Dr. F. D. Holland, paleontologist and stratigrapher in the department, reports that micropaleontological activities since the last news report have been mostly a continuation of studies already begun. Kent Madenwald, Field Inspector for the North Dakota Geological Survey in Williston, is continuing his studies of the foraminifera of outcropping Niobrara (Cretaceous) in North Dakota. He has found a large foraminiferal fauna but, surprisingly, no ostracodes. C. G. Carlson, Geologist with the North Dakota Geological Survey and a graduate student in the department, is nearing the completion of his study of conodonts in the Winnipeg shale (Ordovician). He has tentatively identified two conodont faunas; one seems to be approximately Glenwood in age, and the other approximately Decorah. An even older fauna has been found in the quartzose sandstones of the Deadwood formation in the Williston Basin. The conodonts of the latter fauna are darker than most conodonts and of different composition; they may possibly be of late Cambrian or (more likely) early Ordovician age.

Preliminary investigation of the Chitinozoa of Devonian carbonate formations in the Williston Basin has revealed numerous representa-

tives of these enigmatic microfossils at several horizons in the Devonian, but unfortunately in only relatively few wells. Dr. Mark Rich is continuing his study of fusulinid faunas from the Bird Spring formation (Mississippian, Pennsylvanian, and Permian) northwest of Las Vegas, Nevada. The formation has been zoned on the basis of the fusulinid assemblages. He is also currently engaged in a microscopic textural study of these limestones, which is expected to shed light on the ecological and depositional conditions of the Bird Spring formation.

UNIVERSITY OF MINNESOTA, MINNEAPOLIS

Dr. John W. Hall, in the Department of Botany, reports the following activities in the field of palynology being conducted in that department: John W. Hall is working on the pollen and spore composition of the Dakota group at its type locality in Iowa and Nebraska and of the Windrow formation from outcrops in Minnesota. Mrs. Elizabeth J. Cahoon has collected material from the Inyan Kara group of the southern Black Hills which she will analyze for pollen and spores for her doctoral dissertation. Norman Norton has a pollen and spore assemblage from the Colgate member of the Fox Hills sandstone which he is investigating.

Professor F. M. Swain, Associate Chairman of the Department of Geology, contributes the following research news in micropaleontology: The Ordovician Maquoketa and Dubuque conodonts have been studied by Gerald Webers, with emphasis on assemblages, and his thesis under Robert Sloan is nearing completion. Robert Bright is applying palynology to the interpretation of Pleistocene lake deposits of southeastern Idaho, and Louis Maher is doing similar work in the San Juan Mountains, Colorado. Edward Cushing and Thomas Winter are conducting studies of the Pleistocene pollen sequence in Minnesota. Miss Saskia Jelgersma, of the Geological Survey of Holland, is serving as research fellow in the pollen studies. Elizabeth Cahoon is working on Cretaceous microflora in southwestern Minnesota. Ann McKnight Bent has been assisting H. E. Wright in pollen studies of mountain lakes of the Chuska Mountains, Arizona. Mrs. Bent will do additional work for Professor Wright in Iran during the coming year. A paper on Ordovician Decorah shale Ostracoda has been completed by F. M. Swain, Donald L. Hansen, and James P. Cornell. Ostracoda from the Gulf of California, collected by the Scripps Institute of Oceanography, are being studied by Swain and Richard E. Benson (no relation to Dr. Richard H. Benson of Kansas).

UNIVERSITY OF IOWA, IOWA CITY

Dr. Brian Glenister is now in charge of paleontology at the University of Iowa. He reports that there are now three Ph. D. students working in micropaleontology. V. E. Dow has developed a technique which utilizes the magnetic properties of conodonts to separate them from practically all types of parent residues. The concentration is effected with a Frantz Isodynamic Separator. A manuscript describing the process has been submitted for publication in the Journal of Paleontology.

R. M. Liebe has commenced a study of the Silurian conodonts of the Illinois Basin. The program is partially supported by the Illinois State Geological Survey. Gilbert Klapper has initiated a regional investigation of the Darby formation, with particular emphasis on the conodont faunas of the uppermost shale member. Conodont evidence suggests that the shale member is equivalent to the Clymenia Zone of the Upper Devonian. Collections have been assembled from the Wind River, Absaroka, and Big Horn Mountains. Additional late Upper Devonian strata in Wyoming and Montana will be sampled this summer.

UNIVERSITY OF WICHITA, WICHITA

Dr. Paul Tasch reports that the most recent findings of his N.S.F.-supported paleolimnological research include Leonardian algae found in association with insects and conchostracans. These are now being studied by peel techniques. Several forms not previously described are present in material at hand. Spores are present in many samples collected while tracing and locating clam-shrimp-bearing beds in Kansas and Oklahoma. Plans for the intensive study of these spores in collaboration with a few graduate students are under way. A few molluscan and ostracode coquinas were found in dried muds of ponds and creek beds by a colleague in this research, Dr. J. R. Zimmerman, the ecologist for the project. He found them during a survey of existing ponds in Sedgwick and Harvey Counties, Kansas, last summer. Ostracode muds yielded numerous individuals after two days' submergence in aquarium water.

Other projects under way include a study of Permian scolecodonts recently discovered in a nearby quarry. A joint paper on this fauna by Dr. Tasch and a student assistant, Jerry Stude, was presented at the April, 1960, meeting of the Kansas Academy of Science.

Dr. Tasch also reports progress in his attempt to decipher the animal succession in the basal Maquoketa sea, based on an analysis of the phosphatic pellets of this zone. He is being assisted in this work by a student assistant, Orrin Oftedahl.

THE UNIVERSITY OF KANSAS AND KANSAS GEOLOGICAL SURVEY, LAWRENCE

Dr. Richard Benson reports that there are nine students working on various problems in ostracodes with him, and some working on arenaceous foraminifera with Dr. Ireland. Dr. Benson had a special class in post-Paleozoic ostracodes in 1960 and has been asked to give it again in 1961. He has been engaged in teaching and in supervision of research, and working on the Florida Bay and North Carolina marine ostracodes. He writes: "One project that is very interesting and time-

consuming is the collection, with the cooperation of many colleagues over the world, of samples of Recent sediments containing ostracodes, to study the biogeographic distribution of living genera. The response to my requests for sediments and offers to trade material has been very gratifying. I have been receiving ostracodes from many parts of the world from which ostracodes have never been described. I hope soon to get an idea of the magnitude and limitations of some of the important genera whose variation has caused trouble."

The ostracode volume of the Treatise is in press and may be out by the time this news report is published. Dr. Benson's work on the ecology of the ostracodes of Todos Santos Bay, Baja California, was published in the Kansas Paleontological Contributions last summer.

Particular research projects being carried on at the University include the following: W. Kenneth Pooser is studying the ostracodes and foraminifera of the Miocene and Eocene of South Carolina, in an attempt to solve some of that Survey's stratigraphic problems and complete his Ph. D. at Kansas. Stuart Grossman is completing his Ph. D thesis on the ecology of Recent foraminifera and Ostracoda of Pamlico Sound, North Carolina; he will join Louis Kornicker at Port Aransas in September to study the Recent Ostracodes of that area. Don Bebout has finished his thesis on the Desmoinesian fusulinids of Houston. He will study Lower Cretaceous Ostracodes in thin section. George L. Coleman has finished his study of Recent ostracodes of the eastern Gulf of Mexico, which will be prepared for publication. Edwin Gutentag, a former student, is returning to western Kansas to study Pleistocene and Pliocene Ostracoda for the U.S.G.S. Ground-Water Branch. Jim Tatro is collecting material for a thesis on the Arkansas Cretaceous Ostracoda; this will be a restudy of Israelsky's sections, plus a few new ones. Roger Williams spent the summer of 1960 at the Narragansett Marine Station, studying the Recent Ostracoda of the Narragansett Bay area. Roger Arbour, of Canada, collected Recent ostracodes last summmer around the Gaspé region in the hope of carrying our knowledge of these forms farther toward Greenland. Don Steinker is almost finished with a study of the foraminifera of Florida Bay. This study will be incorporated into Dr. Benson's study of the Ostracoda in order to give a more complete picture of the ecology of the microfauna of that area. Yvon Globensky, another Canadian student, is working, for the second year, on the Mississippian arenaceous foraminifera of the Gaspé region, in eastern Canada. At the Kansas Geological Survey, Dr. Allison Hornbaker is now working in palynology.

UNIVERSITY OF MISSOURI, COLUMBIA

Dr. Raymond Peck, with the assistance of Joe Hazel, a graduate student in the Department, compiled the following news items: Several coal horizons found in the Pennsylvanian sediments of north-central and northeastern Missouri have provided material for three M. A. theses in palynology. Two of these, "Palynology of selected coals of north-central Missouri," by M. D. Mumma, and "Palynology of selected coals of northeastern and north-central Missouri," by W. F. Von Almen, have been completed in the past year. The third, "Palynology of the Mulky coal of Missouri," by R. H. Ingebritsen, is nearing completion.

In addition to these studies of Missouri coals, two other M. A. theses, "An investigation of possibilites of palynologic zonation and correlation of selected Permian salt deposits in Kansas," by B. L. Shaffer, and "Palynology of the Mesa Verde formation of Wyoming," by Ellis Boeringer, are under way.

Charles F. Upshaw (now with the Pan American Oil Company) has completed his dissertation, entitled "Palynology of the Frontier formation, northwestern Wind River Basin, Wyoming." Numerous new species of spores, pollen, dinoflagellates, and hystrichospherids are described. In addition to the systematics, Dr. Upshaw also worked on the determination of marine-nonmarine relationships, comparing abundance percentages of pollen and spores to microplankton.

Conodont research at Missouri includes a completed Ph. D. dissertation by Jesse B. Ellis, entitled "A statistical analysis of conodonts from the Upper Devonian of Missouri"; a completed M. A. thesis by W. L. Brown, "Conodonts from the basal sandstone of the Noel shale of southwestern Missouri"; and an uncompleted M. A. thesis by C. R. Jones, entitled "Speciation of the genus *Pseudopolygnathus* in the lower Hannibal formation." Dr. M. G. Mehl is still involved in an extensive study of the basal Mississippian conodonts of Missouri.

Two M. A. theses involving ostracodes have recently been completed. These are a study of the Cretaceous ostracodes of the Ripley formation (Maestrichtian) of Tennessee, by H. P. Granata, and a taxonomic and paleoecological study of the ostracodes of the Lomita marl (Lower Pleistocene) of California, by J. E. Hazel. Dr. J. W. Valentine and J. E. Hazel have initiated a paleoecological study of the ostracode and molluscan faunas of the Lomita marl.

Raymond E. Peck is continuing his research on the late Cretaceous and Tertiary Charophyta of North America. He is also studying the North American occurrences of the genus *Chovanella* Reitlinger and Yartseva. Representatives of *Chovanella* are widely distributed in the Devonian of the United States and Canada. A short paper, "Stratigraphic distribution of Charophyta and nonmarine ostracods," was published by Peck in the 1959 Annual Field Conference Guidebook of the Intermountain Association of Petroleum Geologists. Only important Mesozoic and Cenozoic genera and species of the Rocky Mountain area were included.

MISSOURI SCHOOL OF MINES AND METALLURGY, ROLLA

Professor Don L. Frizzell writes that interest in micropaleontology has been great over the past year, keeping him extremely busy. Its scope has been increased by the addition of a course at the undergraduate level. Six juniors and seniors were enrolled during 1959–1960, in addition to three graduate students.

Robert C. Thornton is preparing an M. S. thesis on wall structures of arenaceous foraminifera under the supervision of Professor Frizzell. Another M. S. project directly related to micropaleontology is being concluded by Arthur R. Troell, Jr. His study of Mississippian reefs, directed by A. C. Spreng, combines carbonate petrology, stratigraphy-sedimentation, micropaleontology, and paleoecology.

At the faculty level, Professor Frizzell has received a grant of $10,700 from the Earth Sciences Program of the National Science Foundation for a two-year "Taxonomic study of fossil and Recent fish otoliths." The project includes the description of Paleocene to Oligocene faunas of the Gulf Coast area.

WASHINGTON UNIVERSITY, ST. LOUIS

There was an increase in interest in micropaleontology during 1959–1960. Several new students entered the general course and plan to specialize in the field. Some of the research projects mentioned in the previous news report are nearing completion, and others have been completed. A few new programs have been outlined.

Hsin-yi Ling, a Ph. D. candidate, has almost finished his dissertation, "A micropaleontologic and ecologic investigation of two Recent Gulf cores." Core samples, one from Galveston Bay and another from Matagorda Delta, were chosen because of their transitional nature. Both cores are gradational from marine to nonmarine. These Recent cores were selected so that possible relationships between the entire microfauna and -flora and the sediments might be discerned. If relationships are suggested or established from the present study, it may be possible to project the results and find that they are applicable to other areas as well as to older sedimentary deposits. By "relationship" is meant the quantitative and qualitative abundance, size distribution, and generic and specific variation of the foraminifera, the abundance and size distribution of the Ostracoda and their molt stages, and the occurrences and relative abundance of diatoms, Radiolaria, coccoliths, discoasters, hystricospherids, spores and pollen, in connection with the obvious gradual change in depositional environments. Coupled with these micropaleontologic analyses of the samples, the following sedimentary investigations were made: grain-size analysis by a combination of sieve and pipette methods, calcium carbonate content determination by the Versenate method, and the study of clay minerals by X-ray reflection.

Richard Frey, a graduate student in micropaleontology, plans the seasonal collection of fresh-water ostracodes from ponds and lakes in Missouri, for a study for his M. A. thesis. Various techniques of collecting will be used, including the use of SCUBA equipment. This study will involve a quantitative and qualitative analysis of possible variations in ostracodes when factors such as bottom conditions, depth, nutrients, and seasonal changes are taken into consideration.

Other projects under way are as follows: Al Kirschbaum is compiling a check list of Venezuela foraminifera and ostracodes. Don Yatkeman is working on a series of microfaunal slides for comparative use in the laboratory. He is picking samples ranging in age from Cretaceous to Miocene from both the Pacific and Gulf Coast areas. It is hoped that a more intensive analysis of this subject can be made in the near future. George Esker is working on a beautifully preserved silicified Ordovician ostracode fauna. Don Hermes is collecting from Decorah (Ordovician) outcrops for an ostracode and conodont study, and Ronald Schmidt is collecting ostracodes and conodonts from several Kimmswick (Ordovician) outcrops.

The "Microforaminifera of the Little Stave Creek area," by Echols and Schaeffer, was published in MICROPALEONTOLOGY in October, 1960. A brief abstract of this research was given in the previous news report.

A check list of Mississippian, Pennsylvanian, and Permian ostracodes, compiled by Echols and Creath, was published in MICROPALEONTOLOGY in October, 1959. In the fall of 1960 they started a survey of Ordovician, Silurian, and Devonian ostracodes of the United States.

Echols and John Gouty (Shell Oil Company, California) plan to finish the "Re-evaluation of the Ostracoda from the Spergen formation of Missouri" this year. This study involves six Spergen (Mississippian) localities in Missouri.

Due to the kindness and generosity of our many "micro" friends in this country and abroad, our sample collection had some very fine additions during the past year.

DOROTHY JUNG ECHOLS
Washington University
St. Louis, Missouri

VENEZUELA

BOGUSŁAW J. SZENK

CREOLE PETROLEUM CORPORATION

During the past year Creole shut down its eastern Venezuela laboratory in Jusepín and transferred the personnel to Maracaibo, where one laboratory now does all of Creole's paleontological work. John Sulek, James Lamb, and Dr. R. M. Stainforth are now in Maracaibo, where the latter has assumed direction of laboratory activities. Dr. Carlos E. Key, who was in charge of the Maracaibo laboratory, is now devoting his time to regional geological studies. Arthur N. Dusenbury and Jesse J. Howard complete the regular staff. Hugo Ancieta is back from his studies in the U.S.A. and is working on a special project in paleontology. J. W. Funkhouser is on a temporary assignment to help accelerate the program of palynology. Lee Gibson left the laboratory in order to study for a Doctor's degree in palynology under Professor Wilson at the University of Oklahoma. Peter Ronai has also resigned and is living in the Los Angeles area. After having spent 20 years with Creole in Venezuela, Mr. Dusenbury is retiring at the end of 1960.

Dr. Stainforth presented a paper entitled "Estado actual de las correlaciones transatlânticas del Oligo-Mioceno por medio de foraminíferos planctonicos" at the third Venezuelan Geological Congress in Caracas, November, 1959. A modified version was published in Revue de Micropaléontologie (vol. 2, no. 4, pp. 175–180, March, 1960) under the title "Current status of transatlantic Oligo-Miocene correlation by means of planktonic foraminifera." Mr. Dusenbury has continued to correspond with the secretary of the International Commission on Zoological Nomenclature. One of the items was Declaration 40 (vol. 19, pt. 14), concerning the correct gender of certain generic names. Opinion 552 (vol. 20, pt. 19, pp. 214–219) was a statement of the case for validating the family name "Globigerinidae," and Opinion 558 (vol. 20, pt. 25, p. 281) supported the rejection of a 1784 publication for nomenclatorial purposes.

CÍA SHELL DE VENEZUELA

R. W. Pooley, who was in charge of Shell's laboratory in Caracas, left the company on retirement in December, 1959. He was succeeded by B. van Raadshoven, who in turn was transferred in April, 1960, to the Royal Dutch Shell Research Organization in the Netherlands. Dr. Hans M. Bolli, formerly with Venezuelan Atlantic Refining Company, is now in charge of Shell's Caracas laboratory.

W. E. Crews is head of Shell's laboratory for western Venezuela, which is located in Maracaibo. The professional staff consists of a micropaleontologist, A. Ford, and two palynologists, J. H. Germeraad and R. de Haan.

MENE GRANDE OIL COMPANY

Alejandro Euribe, paleontologist with two years of service at MENEG's stratigraphic laboratory in Caracas, accepted a position as head of the laboratory for International Petroleum Company in Talara, Peru. He left Venezuela in July, 1960.

TEXAS PETROLEUM COMPANY

Dr. C. M. B. Caudri, who is in charge of the paleontological laboratory in Caracas, is working mainly on the stratigraphy of western Venezuela. Her study of the larger foraminifera of Trinidad, which is being prepared for publication, is nearing completion. Miss L. M. Balseiro, a member of the Caracas professional staff since 1955, is engaged in minute correlation of wells in eastern Venezuela.

VENEZUELAN ATLANTIC REFINING COMPANY

The paleontological laboratory of this company, which was headed by Dr. Hans M. Bolli, was closed at the end of February, 1960.

MINISTERIO DE MINAS É HIDROCARBUROS

Dr. Pedro Bermudez presented a paper at the Third Venezuelan Geological Congress, entitled "Contribución al estudio de los foraminíferos planctonicos de la región Caribe-Antillana." It will be published by the Ministry in the near future.

ASOCIACIÓN VENEZOLANA DE GEOLOGÍA, MINERÍA Y PETRÓLEO (AVGMP)

Gordon A. Young, stratigrapher with Mene Grande's stratigraphic laboratory in Caracas and assistant editor of AVGMP's monthly publication, the "Boletin Informativo," which has a circulation of 600 copies, has been named by the International Geological Abstracting Service as its regional coordinator for Venezuela. Wade H. Hadley, also a stratigrapher with MENEG's stratigraphic laboratory, is preparing a paper on the "Biostratigraphy of the La Pica formation—Eastern Venezuela." This paper will form part of a symposium on the La Pica formation to be presented at the Association's annual meeting in March, 1961.

CONSULTANTS

Frank Amato, consultant in stratigraphy and micropaleontology, is currently devoting the majority of his efforts to subsurface studies in the Gulf of Paria.

BOGUSŁAW J. SZENK
Mene Grande Oil Company
Caracas